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[Continued on next page]

**(54) Title: SYNTHETIC HYPERGLYCOSYLATED, PROTEASE-RESISTANT POLYPEPTIDE VARIANTS, ORAL FORMULATIONS AND METHODS OF USING THE SAME**

[illegible]

**(57) Abstract:** The present invention provides synthetic Type I interferon receptor polypeptide agonists comprising consensus or hybrid Type I interferon receptor polypeptide agonists, containing one or more native or non-native glycosylation sites. The present invention further provides oral formulations of protease-resistant or protease-resistant, hyperglycosylated polypeptide variants, which polypeptide variants lack at least one protease cleavage site found in a parent polypeptide, and thus exhibit increased protease resistance compared to the parent polypeptide, which polypeptide variants further include (1) a carbohydrate moiety covalently linked to at least one non-native glycosylation site not found in the parent protein therapeutic or (2) a carbohydrate moiety covalently linked to at least one native glycosylation site

found but not glycosylated in the parent protein therapeutic. The present invention further provides compositions, including oral pharmaceutical compositions, comprising the synthetic Type I interferon receptor polypeptide agonist, the hyperglycosylated polypeptide variant, the protease-resistant polypeptide variant, or the hyperglycosylated, protease-resistant polypeptide variant. The present invention further provides containers, devices, and kits comprising the synthetic Type I interferon receptor polypeptide agonist, the hyperglycosylated polypeptide variant, the protease-resistant polypeptide variant, or the hyperglycosylated, protease-resistant polypeptide variant. The present invention further provides therapeutic methods involving administering an effective amount of an oral pharmaceutical composition comprising a synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant to an individual in need thereof.



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**SYNTHETIC HYPERGLYCOSYLATED, PROTEASE-RESISTANT POLYPEPTIDE VARIANTS,  
ORAL FORMULATIONS AND METHODS OF USING THE SAME**

**FIELD OF THE INVENTION**

**[0001]** The present invention is in the field of glycosylated, protease-resistant and glycosylated protease-resistant protein therapeutics.

**BACKGROUND OF THE INVENTION**

**[0002]** The use of proteins as therapeutic agents has gained in clinical importance. Nevertheless, there remain various obstacles and drawbacks to their use, including immunogenicity; destruction of the therapeutic protein by enzymes produced by the host; suboptimal pharmacokinetic properties; and the like. For example, immunogenicity of a therapeutic protein can lead to neutralization of the protein's activity by neutralizing antibodies generated over time in the subject being treated. In addition, immunogenicity of a therapeutic protein can lead to an inflammatory response. Destruction of a therapeutic protein by host enzymes may preclude the use of certain routes of administration. For example, oral administration of therapeutic proteins may be desirable in treating certain conditions; however, the therapeutic protein may be destroyed by enzymes in the gastrointestinal tract of the individual being treated. Furthermore, a therapeutic protein may have a short serum half life, due, e.g., to rapid elimination of the protein by the host reticuloendothelial system; as a consequence, the pharmacokinetic profile of the therapeutic protein may be such that repeated, frequent administration is necessary.

**[0003]** Many proteins with therapeutic potential include one or more glycosylation sites, e.g., amino acid sequences that are glycosylated by a eukaryotic cell. There have been various reports of attempts to increase the degree of glycosylation of therapeutic proteins in order to achieve 1) reduced immunogenicity; 2) less frequent administration of the protein; 3) increased serum half-life; and 4) reduction in adverse side effects such as inflammation.

**[0004]** Destruction of a therapeutic protein by host enzymes may preclude the use of certain routes of administration. For example, oral administration of therapeutic proteins may be desirable in treating certain conditions; however, the therapeutic protein may be destroyed by proteolytic enzymes in the gastrointestinal tract and/or in the serum of the individual being treated. Such proteolytic enzymes include, e.g.,  $\alpha$ -chymotrypsin, carboxypeptidase, endoproteinase Arg-C, endoproteinase Asp-N, endoproteinase Glu-C, endoproteinase Lys-C, and trypsin.

[0005] There is a need in the art for therapeutic proteins in oral dosage forms having suitable pharmacokinetic properties. The present invention addresses this need.

Literature

[0006] U.S. Patent No. 6,685,933; U.S. Patent Nos. 4,695,623 and 4,897,471; U.S. Patent No. 6,703,225; U.S. Patent No. 6,569,420; U.S. Patent No. 6,299,877; U.S. Patent No. 6,586,398; U.S. Patent No. 6,531,122; U.S. Patent No. 6,646,110; Egrie and Brown, Br J Cancer. 2001 Apr;84 Suppl 1:3-10; U.S. Patent No. 6,127,332; WO 00/26354; WO 02/081507; WO 01/36001; U.S. Patent No. 5,041,376; U.S. Patent No. 5,520,911; U.S. Patent No. 6,673,580; U.S. Patent No. 5,853,724; European Patent Application No. 640,619; WO 04/022747; and WO 004/0222593. Nyman et al. (1998) *Eur. J. Biochem.* 253:485-493; Runkel et al. (1998) *Pharmaceutical Research* 15:641; Adolf et al. (1990) *J. Biol. Chem.* 265:9290-9295.

**SUMMARY OF THE INVENTION**

[0007] The present invention provides non-native glycosylation sites, oral formulations of protease-resistant polypeptide variants and protease-resistant or protease-resistant, hyperglycosylated polypeptide variants, which polypeptide variants comprise at least one mutated protease cleavage site in place of a native protease cleavage site found in a parent polypeptide, and thus exhibit increased protease resistance compared to the parent polypeptide, which polypeptide variants further include (1) a carbohydrate moiety covalently linked to at least one non-native glycosylation site not found in the parent protein therapeutic or (2) a carbohydrate moiety covalently linked to at least one native glycosylation site found but not glycosylated in the parent protein therapeutic. The present invention further provides compositions, including oral pharmaceutical compositions, comprising the glycosylated or protease-resistant or protease-resistant, hyperglycosylated polypeptide variants. The present invention further provides nucleic acids comprising nucleotide sequences encoding subject polypeptide agonists; and host cells comprising subject nucleic acids. The present invention further provides methods of treating viral infections, methods of treating fibrotic disorders, and methods of treating proliferative disorders, the methods generally involving administering to an individual in need thereof an effective amount of a subject polypeptide agonist. The present invention further provides containers, devices, and kits comprising the hyperglycosylated or protease-resistant or protease-resistant, hyperglycosylated polypeptide variants. The present invention further provides therapeutic methods involving administering an effective amount of an oral pharmaceutical composition comprising a hyperglycosylated or protease-resistant or protease-resistant, hyperglycosylated polypeptide variant to an individual in need thereof.

**FEATURES OF THE INVENTION**

- [0008] In one aspect, the invention provides oral pharmaceutical compositions comprising a known hyperglycosylated or protease-resistant or protease-resistant, hyperglycosylated variant of a parent protein therapeutic.
- [0009] In another aspect, the invention provides an oral pharmaceutical composition that contains a first number of moles of the known hyperglycosylated or protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in a first unit form, where a parenteral pharmaceutical composition containing a second number of moles of the parent protein therapeutic is proven to be effective in the treatment of a disease in a patient when administered to the patient by subcutaneous bolus injection in an amount where the patient receives the second number of moles of the parent protein therapeutic at a selected dosing interval, where the first number of moles is greater than the second number of moles, and where upon oral administration of the first unit form to the patient, the time required for release of the first number of moles of the hyperglycosylated or protease-resistant or protease-resistant, hyperglycosylated variant is no greater than the time period of the selected dosing interval.
- [0010] In another aspect, the invention provides an oral pharmaceutical composition that contains a first dose of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in a first unit form, where a parenteral pharmaceutical composition containing a second dose of the parent protein therapeutic is proven to be effective in the treatment of a disease in a patient when administered to the patient by subcutaneous bolus injection of the second dose at a selected dosing interval, where the amount of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in moles of drug per kilogram of patient body weight in the first dose is greater than the amount of the parent protein therapeutic in moles of drug per kilogram of patient body weight in the second dose when the first and second doses are calculated for the average patient body weight in the total population of patients suffering from the disease, and where upon oral administration of the first dose to the patient, the time required for release of all of the protease-resistant or protease-resistant, hyperglycosylated variant in the first dose is no greater than the period of time between doses in the selected dosing interval. In some embodiments, the parenteral pharmaceutical composition is proven to be effective in the treatment of the disease in the patient when administered to the patient in a weight-based dose at the selected dosing interval, i.e., the second dose is a weight-based dose and the parenteral pharmaceutical composition is in a form that allows weight-based dosing.

[0011] The present invention further provides therapeutic methods involving administering an effective amount of an oral pharmaceutical composition comprising a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant to an individual in need thereof.

[0012] In another aspect, the invention provides a method of treating a disease in a patient comprising administering to the patient an oral pharmaceutical composition comprising a known, protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic, where the oral pharmaceutical composition is administered orally to the patient in an amount whereby the patient receives a first dose of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at a first dosing interval, where a parenteral pharmaceutical composition comprising the parent protein therapeutic is proven to be effective in the treatment of the disease in a patient when administered to the patient by subcutaneous bolus injection in an amount whereby the patient receives a second dose of the parent protein therapeutic at a second dosing interval, where the first dose in moles of the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant per kilogram of patient body weight is greater than the second dose in moles of the parent protein therapeutic per kilogram of patient body weight when the first and second doses are calculated for the same patient body weight, and where upon oral administration of the first dose to the patient, the time required for release of all of the protease-resistant or protease-resistant, hyperglycosylated variant in the first dose is no greater than the period of time between doses in the second dosing interval. In some embodiments, the parenteral pharmaceutical composition is proven to be effective in the treatment of the disease in the patient when administered to the patient in a weight-based dose at the second dosing interval, i.e., the second dose is a weight-based dose and the parenteral pharmaceutical composition is in a form that allows weight-based dosing. In some of the foregoing embodiments, the first dose is a weight-based dose and the oral pharmaceutical composition is in a form that allows weight-based dosing.

[0013] In another aspect, the invention provides a method of treating a disease in a patient comprising administering to the patient an oral pharmaceutical composition comprising a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic, where the oral pharmaceutical composition is administered orally in an amount whereby the patient receives a first dose of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at a first dosing interval, where a parenteral pharmaceutical composition comprising the parent protein therapeutic is proven to be effective in the treatment of the disease in a patient when administered to the patient by

subcutaneous bolus injection in an amount whereby the patient receives a second dose of the parent protein therapeutic at a second dosing interval, where the first dose in moles of the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant per kilogram of patient body weight is greater than the second dose in moles of the parent protein therapeutic per kilogram of patient body weight when the first and second doses are calculated for the same patient body weight, and where the time period between doses in the first dosing interval is the same as or shorter than the time period between doses in the second dosing interval. In some embodiments, the parenteral pharmaceutical composition is proven to be effective in the treatment of the disease in the patient when administered to the patient in a weight-based dose at the second dosing interval, i.e., the second dose is a weight-based dose and the parenteral pharmaceutical composition is in a form that allows weight-based dosing. In some of the foregoing embodiments, the first dose is a weight-based dose and the oral pharmaceutical composition is in a form that allows weight-based dosing.

[0014] In another aspect, the invention provides a method of treating a disease in a patient comprising administering to the patient an oral pharmaceutical composition in a first unit form comprising a first number of moles of a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic, where the first number of moles of the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is greater than a second number of moles of the parent protein therapeutic in a parenteral pharmaceutical composition, where the parenteral pharmaceutical composition is an immediate release formulation suitable for subcutaneous bolus injection, where the first unit form is administered orally to the patient at a first dosing interval that is the same as or shorter than a second dosing interval, and where the parent protein therapeutic is proven to be effective in the treatment of the disease in a patient when administered to the patient by subcutaneous bolus injection of the parenteral pharmaceutical composition in an amount whereby the patient receives the second number of moles of the parent protein therapeutic at the second dosing interval.

#### BRIEF DESCRIPTION OF THE DRAWINGS

- [0015] **Figure 1** depicts an amino acid sequence of human mature IFN- $\alpha$ 2a.  
[0016] **Figure 2** depicts an amino acid sequence of human mature IFN- $\alpha$ 2b.  
[0017] **Figure 3** depicts an amino acid sequence of human IFN- $\beta$ .  
[0018] **Figure 4** depicts an amino acid sequence of mature, native human IFN- $\gamma$ .  
[0019] **Figure 5** depicts an amino acid sequence of G-CSF.

- [0020] Figure 6 depicts an amino acid sequence of human growth hormone.
- [0021] Figure 7 depicts an amino acid sequence of erythropoietin.
- [0022] Figure 8 depicts an amino acid sequence of GM-CSF.
- [0023] Figure 9 depicts an amino acid sequence of a consensus IFN- $\alpha$ .
- [0024] Figure 10 depicts an amino acid sequence of IFN- $\alpha$ c.
- [0025] Figure 11 depicts an amino acid sequence of IFN- $\alpha$ 2c.
- [0026] Figure 12 depicts an amino acid sequence of IFN- $\alpha$ d.
- [0027] Figure 13 depicts an amino acid sequence of IFN- $\alpha$ 5.
- [0028] Figure 14 depicts an amino acid sequence of IFN- $\alpha$ 6.
- [0029] Figure 15 depicts an amino acid sequence of IFN- $\alpha$ 4.
- [0030] Figure 16 depicts an amino acid sequence of IFN- $\alpha$ 4b.
- [0031] Figure 17 depicts an amino acid sequence of IFN- $\alpha$ I.
- [0032] Figure 18 depicts an amino acid sequence of IFN- $\alpha$  J.
- [0033] Figure 19 depicts an amino acid sequence of IFN- $\alpha$ H.
- [0034] Figure 20 depicts an amino acid sequence of IFN- $\alpha$ F.
- [0035] Figure 21 depicts an amino acid sequence of IFN- $\alpha$ 8.
- [0036] Figure 22 depicts an amino acid sequence of IFN- $\beta$ 1.
- [0037] Figure 23 depicts an amino acid sequence of IFN- $\beta$ 2a.
- [0038] Figure 24 depicts an amino acid sequence comparison of Infergen (SEQ ID NO:\*\*) and Type I Interferon species (human IFN- $\alpha$ 2b, SEQ ID NO:2; human IFN- $\alpha$ 14, SEQ ID NO:\*\*; human IFN- $\beta$ 1, SEQ ID NO:\*\*; human IFN- $\omega$ 1, SEQ ID NO:\*\*) that have been reported to be glycosylated naturally. The amino acid residues where the glycosylations occur are labeled with bold outlined boxes. The asparagines residues are the anchoring site for N-linked glycosylation and the threonine residue is the anchoring site for O-linked glycosylation. Figure 24 also depicts a majority sequence (SEQ ID NO:\*\*) based on the comparison.
- [0039] Figure 25 depicts an amino acid sequence comparison of amino acids 61-120 of Infergen (SEQ ID NO:\*\*) and exemplary synthetic Type I interferon receptor polypeptide agonists. Sites 1, 2 and 3 are examples of positions where glycosylation sites are created. N-linked glycosylation sites are generated at Sites 1 and 2. Both N-linked and O-linked glycosylation sites are generated at Site 3.
- [0040] Figure 26 depicts a synthetic mammalian Infergen nucleic acid sequence with preferred human codon usage; and the translated open reading frame (SEQ ID NO:\*\*). The open reading frame is indicated with translated Infergen amino acid sequence (SEQ ID NO:1). Six pairs of complementary primers from A to F are shown in alternating italics and bold text.

The upper sense strands of the primer pairs are identified with odd number and lower non-sense strands are identified with even number. In the region upstream of the start codon ATG, a short sequence of GCCACC, the Kozak consensus sequence, is designed to increase eukaryotic translation efficiency. Two tandem stop codons -- TAA and TGA -- are used to ensure complete termination of translation.

- [0041] **Figure 27** depicts a comparison of the nucleic acid sequences of mammalian Infergen and glycosylated mutants thereof. The nucleotides that differ are shown in boxes. Codons used based on the preferred codon usage set forth in Table 8.
- [0042] **Figure 28** depicts an amino acid sequence comparison of amino acids 81-140 of human IFN- $\beta$ 1 (SEQ ID NO:\*\*) and exemplary glycosylated variants of human IFN- $\beta$ 1. Sites 1 and 2 are the positions where glycosylation mutants are generated. In general, only N-linked glycosylation sites are created at Site 1. Both N-linked and O-linked glycosylation sites are generated at Site 2. The naturally occurring N-linked glycosylation sites in human IFN- $\beta$ 1 and mutants are shown in boxes.
- [0043] **Figure 29** depicts an amino acid sequence comparison of amino acids 81-140 of human IFN- $\omega$ 1 (SEQ ID NO:\*\*) and exemplary glycosylated variants of human IFN- $\omega$ 1. Sites 1 and 2 are the positions where glycosylation mutants are generated. In general, only N-linked glycosylation sites are created at Site 1. Both N-linked and O-linked glycosylation sites are generated at Site 2. The naturally occurring N-linked glycosylation sites in human IFN- $\omega$ 1 and mutants are shown in boxes.
- [0044] **Figure 30** depicts an amino acid sequence alignment of Infergen (SEQ ID NO:\*\*), human IFN- $\alpha$ 14 (SEQ ID NO:\*\*), human IFN- $\beta$ 1 (SEQ ID NO:\*\*), and exemplary fusion proteins with human IFN- $\alpha$  14 and human IFN- $\beta$  signal peptides (SEQ ID NOs: \*\* and \*\*, respectively). The majority sequence is shown above (SEQ ID NO: \*\*).
- [0045] **Figure 31** depicts the amino acid sequence of mature, native human IFN- $\gamma$  (SEQ ID NO: \*\*).
- [0046] **Figure 32** depicts Western blot analysis of exemplary proteins synthesized by Cos-7 cells.

#### DEFINITIONS

- [0047] The term "polypeptide" refers to a polymer of amino acids and does not refer to a specific length of the product; thus, peptides, oligopeptides, and proteins are included within the definition of polypeptide. This term also does not refer to or exclude post-translational modifications of the polypeptide, for example, glycosylations, acetylations, phosphorylations

and the like. Included within the term "polypeptide" are, for example, polypeptides containing one or more analogs of an amino acid (including, for example, unnatural amino acids, non-coded amino acids, etc.), polypeptides with substituted linkages, as well as other modifications known in the art, both naturally occurring and non-naturally occurring. The term "polypeptide" includes fusion proteins, including, but not limited to, fusion proteins with a heterologous amino acid sequence, fusions with heterologous and homologous leader sequences, with or without N-terminal methionine residues; immunologically tagged proteins; and the like.

[0048] The terms "polynucleotide" and "nucleic acid molecule" are used interchangeably herein to refer to polymeric forms of nucleotides of any length. The polynucleotides may contain deoxyribonucleotides, ribonucleotides, and/or their analogs. Nucleotides may have any three-dimensional structure, and may perform any function, known or unknown. The term "polynucleotide" includes single-, double-stranded and triple helical molecules.

"Oligonucleotide" generally refers to polynucleotides of between about 5 and about 100 nucleotides of single- or double-stranded DNA. However, for the purposes of this disclosure, there is no upper limit to the length of an oligonucleotide. Oligonucleotides are also known as oligomers or oligos and may be isolated from genes, or chemically synthesized by methods known in the art. The term "polynucleotide" includes double-stranded DNA found, *inter alia*, in linear DNA molecules (e.g., restriction fragments), viruses, plasmids, and chromosomes.

[0049] The following are non-limiting embodiments of polynucleotides: a gene or gene fragment, exons, introns, mRNA, tRNA, rRNA, ribozymes, cDNA, recombinant polynucleotides, branched polynucleotides, plasmids, vectors, isolated DNA of any sequence, isolated RNA of any sequence, nucleic acid probes, and primers. A nucleic acid molecule may also comprise modified nucleic acid molecules, such as methylated nucleic acid molecules and nucleic acid molecule analogs. Analogs of purines and pyrimidines are known in the art. Nucleic acids may be naturally occurring, *e.g.* DNA or RNA, or may be synthetic analogs, as known in the art. Such analogs may be preferred for use as probes because of superior stability under assay conditions. Modifications in the native structure, including alterations in the backbone, sugars or heterocyclic bases, have been shown to increase intracellular stability and binding affinity. Among useful changes in the backbone chemistry are phosphorothioates; phosphorodithioates, where both of the non-bridging oxygens are substituted with sulfur; phosphoroamidites; alkyl phosphotriesters and boranophosphates. Achiral phosphate derivatives include 3'-O'-5'-S-phosphorothioate, 3'-S-5'-O-phosphorothioate, 3'-CH<sub>2</sub>-5'-O-phosphonate and 3'-NH-5'-O-phosphoroamidate. Peptide nucleic acids replace the entire ribose phosphodiester backbone with a peptide linkage.



- [0050] A polynucleotide or polypeptide has a certain percent "sequence identity" to another polynucleotide or polypeptide, meaning that, when aligned, that percentage of bases or amino acids are the same when comparing the two sequences. Sequence similarity can be determined in a number of different manners. To determine sequence identity, sequences can be aligned using the methods and computer programs, including BLAST, available over the world wide web at [ncbi.nlm.nih.gov/BLAST](http://ncbi.nlm.nih.gov/BLAST). See, e.g., Altschul *et al.* (1990), *J. Mol. Biol.* 215:403-10. Another alignment algorithm is FASTA, available in the Genetics Computing Group (GCG) package, from Madison, Wisconsin, USA, a wholly owned subsidiary of Oxford Molecular Group, Inc. Other techniques for alignment are described in *Methods in Enzymology*, vol. 266: Computer Methods for Macromolecular Sequence Analysis (1996), ed. Doolittle, Academic Press, Inc., a division of Harcourt Brace & Co., San Diego, California, USA. Of particular interest are alignment programs that permit gaps in the sequence. The Smith-Waterman is one type of algorithm that permits gaps in sequence alignments. See *Meth. Mol. Biol.* 70: 173-187 (1997). Also, the GAP program using the Needleman and Wunsch alignment method can be utilized to align sequences. See *J. Mol. Biol.* 48: 443-453 (1970)
- [0051] The term "host cell" includes an individual cell or cell culture, which can be or has been a recipient of any recombinant vector(s) or synthetic or exogenous polynucleotide. Host cells include progeny of a single host cell, and the progeny may not necessarily be completely identical (in morphology or in total DNA complement) to the original parent cell due to natural, accidental, or deliberate mutation and/or change. A host cell includes cells transfected or infected *in vivo* or *in vitro* with a recombinant vector or a synthetic or exogenous polynucleotide. A host cell which comprises a recombinant vector of the invention is a "recombinant host cell." In some embodiments, a host cell is a prokaryotic cell. In other embodiments, a host cell is a eukaryotic cell.
- [0052] The terms "DNA regulatory sequences," and "regulatory elements," used interchangeably herein, refer to transcriptional and translational control sequences, such as promoters, enhancers, polyadenylation signals, terminators, protein degradation signals, and the like, that provide for and/or regulate expression of a coding sequence and/or production of an encoded polypeptide in a host cell.
- [0053] The term "transformation" is used interchangeably herein with "genetic modification" and refers to a permanent or transient genetic change induced in a cell following introduction of new nucleic acid (i.e., DNA exogenous to the cell). Genetic change ("modification") can be accomplished either by incorporation of the new DNA into the genome of the host cell, or by transient or stable maintenance of the new DNA as an episomal element. Where the cell is a

mammalian cell, a permanent genetic change is generally achieved by introduction of the DNA into the genome of the cell.

[0054] The term “operably linked,” as used herein, refers to a juxtaposition wherein the components so described are in a relationship permitting them to function in their intended manner. For instance, a promoter is operably linked to a coding sequence if the promoter effects transcription or expression of the coding sequence.

[0055] The term “construct,” as used herein, refers to a recombinant nucleic acid, generally recombinant DNA, that has been generated for the purpose of the expression of a specific nucleotide sequence(s), or is to be used in the construction of other recombinant nucleotide sequences.

[0056] As used herein, the terms “treatment,” “treating,” and the like, refer to obtaining a desired pharmacologic and/or physiologic effect. The effect may be prophylactic in terms of completely or partially preventing a disease or symptom thereof and/or may be therapeutic in terms of a partial or complete cure for a disease and/or adverse affect attributable to the disease. “Treatment,” as used herein, covers any treatment of a disease in a mammal, particularly in a human, and includes: (a) increasing survival time; (b) decreasing the risk of death due to the disease; (c) preventing the disease from occurring in a subject which may be predisposed to the disease but has not yet been diagnosed as having it; (d) inhibiting the disease, i.e., arresting its development (e.g., reducing the rate of disease progression); and (e) relieving the disease, i.e., causing regression of the disease.

[0057] The terms “individual,” “host,” “subject,” and “patient,” used interchangeably herein, refer to a mammal, including primates, rodents, livestock, pets, horses, etc. In some embodiments, an individual is a human.

[0058] The term “therapeutically effective amount” is meant an amount of a therapeutic agent, or a rate of delivery of a therapeutic agent, effective to facilitate a desired therapeutic effect. The precise desired therapeutic effect will vary according to the condition to be treated, the formulation to be administered, and a variety of other factors that are appreciated by those of ordinary skill in the art.

[0059] As used herein, the terms “proven to be effective” in the context of a drug therapy for treatment of a disease, or any language of similar meaning, shall be understood to mean that the drug therapy so described was found to be safe and effective, alone or in combination with one or more additional pharmaceutical agent(s), for the treatment of the disease in a controlled clinical trial or set of clinical trials that achieved one or more of the primary clinical endpoints of the trial(s) with a statistical significance of  $p \leq 0.05$ . Typically, drug therapies proven to be

effective for a drug include: (1) any treatment indication(s) for the drug specified in a license to market the drug granted by a regulatory authority; and (2) any treatment indication(s) for the drug described in a statement issued by a generally recognized body of medical experts (e.g. an NIH Consensus Statement).

[0060] The term “binds specifically,” in the context of antibody binding, refers to high avidity and/or high affinity binding of an antibody to a specific polypeptide i.e., epitope of a polypeptide, e.g., a subject synthetic Type I interferon receptor polypeptide agonist. For example, antibody binding to an epitope on a specific a subject synthetic Type I interferon receptor polypeptide agonist or fragment thereof is stronger than binding of the same antibody to any other epitope, particularly those which may be present in molecules in association with, or in the same sample, as the specific polypeptide of interest, e.g., binds more strongly to a specific subject synthetic Type I interferon receptor polypeptide agonist epitope than to any other Type I interferon receptor polypeptide agonist epitope so that by adjusting binding conditions the antibody binds almost exclusively to the specific subject synthetic Type I interferon receptor polypeptide agonist epitope and not to any other Type I interferon receptor polypeptide agonist epitope, or to any other polypeptide which does not comprise the epitope. Antibodies that bind specifically to a polypeptide may be capable of binding other polypeptides at a weak, yet detectable, level (e.g., 10% or less of the binding shown to the polypeptide of interest). Such weak binding, or background binding, is readily discernible from the specific antibody binding to a subject polypeptide, e.g. by use of appropriate controls. In general, specific antibodies bind to a given polypeptide with a binding affinity of  $10^{-7}$  M or more, e.g.,  $10^{-8}$  M or more (e.g.,  $10^{-9}$  M,  $10^{-10}$  M,  $10^{-11}$  M, etc.). In general, an antibody with a binding affinity of  $10^{-6}$  M or less is not useful in that it will not bind an antigen at a detectable level using conventional methodology currently used.

[0061] A “fibrotic condition,” “fibrotic disease” and “fibrotic disorder” are used interchangeably to refer to a condition, disease or disorder that is amenable to treatment by administration of a compound having anti-fibrotic activity. Fibrotic disorders include, but are not limited to, pulmonary fibrosis, including idiopathic pulmonary fibrosis (IPF) and pulmonary fibrosis from a known etiology, liver fibrosis, and renal fibrosis. Other exemplary fibrotic conditions include musculoskeletal fibrosis, cardiac fibrosis, post-surgical adhesions, scleroderma, glaucoma, and skin lesions such as keloids.

[0062] The term “proliferative disorder” and “proliferative disease” are used interchangeably to refer to any disease or condition characterized by pathological cell growth or proliferation, particularly cancer.

- [0063] The terms "cancer," "neoplasm," and "tumor" are used interchangeably herein to refer to cells that exhibit relatively autonomous growth, so that they exhibit an aberrant growth phenotype characterized by a significant loss of control of cell proliferation. Cancerous cells can be benign or malignant.
- [0064] The term "hepatitis virus infection" refers to infection with one or more of hepatitis A, B, C, D, or E virus, with blood-borne hepatitis viral infection being of particular interest, particularly hepatitis C virus infection.
- [0065] The term "sustained viral response" (SVR; also referred to as a "sustained response" or a "durable response"), as used herein, refers to the response of an individual to a treatment regimen for HCV infection, in terms of serum HCV titer. Generally, a "sustained viral response" refers to no detectable HCV RNA (e.g., less than about 500, less than about 200, or less than about 100 genome copies per milliliter serum) found in the patient's serum for a period of at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, or at least about six months following cessation of treatment.
- [0066] The term "treatment failure patients" (or "treatment failures") as used herein generally refers to HCV-infected patients who failed to respond to previous therapy for HCV (referred to as "non-responders") or who initially responded to previous therapy, but in whom the therapeutic response was not maintained (referred to as "relapsers"). The previous therapy generally can include treatment with IFN- $\alpha$  monotherapy or IFN- $\alpha$  combination therapy, where the combination therapy may include administration of IFN- $\alpha$  and an antiviral agent such as ribavirin.
- [0067] The term "dosing event" as used herein refers to administration of an antiviral agent to a patient in need thereof, which event may encompass one or more releases of an antiviral agent from a drug dispensing device. Thus, the term "dosing event," as used herein, includes, but is not limited to, installation of a continuous delivery device (e.g., a pump or other controlled release injectable system); and a single subcutaneous injection followed by installation of a continuous delivery system.
- [0068] "Patterned" or "temporal" as used in the context of drug delivery is meant delivery of drug in a pattern, generally a substantially regular pattern, over a pre-selected period of time (e.g., other than a period associated with, for example a bolus injection). "Patterned" or "temporal" drug delivery is meant to encompass delivery of drug at an increasing, decreasing, substantially constant, or pulsatile, rate or range of rates (e.g., amount of drug per unit time, or

volume of drug formulation for a unit time), and further encompasses delivery that is continuous or substantially continuous, or chronic.

[0069] The term "controlled drug delivery device" is meant to encompass any device wherein the release (e.g., rate, timing of release) of a drug or other desired substance contained therein is controlled by or determined by the device itself and not substantially influenced by the environment of use, or releasing at a rate that is reproducible within the environment of use.

[0070] By "substantially continuous" as used in, for example, the context of "substantially continuous infusion" or "substantially continuous delivery" is meant to refer to delivery of drug in a manner that is substantially uninterrupted for a pre-selected period of drug delivery, where the quantity of drug received by the patient during any 8 hour interval in the pre-selected period never falls to zero. Furthermore, "substantially continuous" drug delivery can also encompass delivery of drug at a substantially constant, pre-selected rate or range of rates (e.g., amount of drug per unit time, or volume of drug formulation for a unit time) that is substantially uninterrupted for a pre-selected period of drug delivery.

[0071] As used herein, the term "pirfenidone" refers to 5-methyl-1-phenyl-2-(1H)-pyridone. As used herein, the term "pirfenidone analog" refers to any compound of Formula I, IIA, or IIB, below. A "specific pirfenidone analog," and all grammatical variants thereof, refers to, and is limited to, each and every pirfenidone analog shown in Table 10.

[0072] The term "anti-fibrotic" agent, drug or compound is meant to encompass agents that prevent or reduce fibrosis, including: Type II interferon receptor agonists (e.g. interferon-gamma); pirfenidone and pirfenidone analogs; anti-angiogenic agents, such as VEGF antagonists, VEGF receptor antagonists, bFGF antagonists, bFGF receptor antagonists, TGF-beta antagonists, and TGF-beta receptor antagonists; and anti-inflammatory agents, including tumor necrosis factor (TNF) antagonists, such as anti-TNF antibodies (e.g. REMICADE™ anti-TNF monoclonal antibody) and soluble TNF receptor (e.g. ENBREL™ TNF receptor-Ig immunoadhesin), and IL-1 antagonists, such as IL-1Ra.

[0073] The terms "angiogenic agent," "angiogenic compound," and "angiogenic factor" are meant to include agents that promote neovascularization, such as VEGF, bFGF, and TGF-beta.

[0074] The terms "anti-angiogenic" or "angiostatic" agent, drug or compound, or "angiogenesis inhibitor," are meant to include agents that prevent or reduce neovascularization, such as VEGF antagonists, VEGF receptor antagonists, bFGF antagonists, bFGF receptor antagonists, TGF-beta antagonists, and TGF-beta receptor antagonists.

[0075] As used herein, the term "nucleoside" refers to a compound composed of any pentose or modified pentose moiety attached to a specific position of a heterocycle or to the natural

position of a purine (9-position) or pyrimidine (1-position) or to the equivalent position in an analog.

[0076] As used herein, the term "nucleotide" refers to a phosphate ester substituted on the 5'-position of a nucleoside.

[0077] As used herein, the term "heterocycle" refers to a monovalent saturated or unsaturated carbocyclic radical having at least one hetero atom, such as N, O, S, Se or P, within the ring, each available position of which can be optionally substituted, independently, with, e.g., hydroxyl, oxo, amino, imino, lower alkyl, bromo, chloro and/or cyano. Included within the term "heterocycle" are purines and pyrimidines.

[0078] As used herein, the term "purine" refers to nitrogenous bicyclic heterocycles.

[0079] As used herein, the term "pyrimidine" refers to nitrogenous monocyclic heterocycles.

[0080] As used herein, the term "L-nucleoside" refers to a nucleoside compound that has an L-ribose sugar moiety.

[0081] The term "antineoplastic" agent, drug or compound is meant to refer to any agent, including any chemotherapeutic agent, biological response modifier (including without limitation (i) proteinaceous, i.e. peptidic, molecules capable of elaborating or altering biological responses and (ii) non-proteinaceous, i.e. non-peptidic, molecules capable of elaborating or altering biological responses), cytotoxic agent, or cytostatic agent, that reduces proliferation of a neoplastic cell.

[0082] The term "anti-fibrotic" agent, drug or compound is meant to encompass agents that prevent or reduce fibrosis, including: Type II interferon receptor agonists (e.g. interferon-gamma); pirfenidone and pirfenidone analogs; anti-angiogenic agents, such as VEGF antagonists, VEGF receptor antagonists, bFGF antagonists, bFGF receptor antagonists, TGF-beta antagonists, and TGF-beta receptor antagonists; and anti-inflammatory agents, including tumor necrosis factor (TNF) antagonists, such as anti-TNF antibodies (e.g. REMICADE™ anti-TNF monoclonal antibody) and soluble TNF receptor (e.g. ENBREL™ TNF receptor-Ig immunoadhesin), and IL-1 antagonists, such as IL-1Ra.

[0083] The term "chemotherapeutic agent" or "chemotherapeutic" (or "chemotherapy", in the case of treatment with a chemotherapeutic agent) is meant to encompass any non-proteinaceous (i.e., non-peptidic) chemical compound useful in the treatment of cancer. Examples of chemotherapeutic agents include alkylating agents such as thiotepa and cyclophosphamide (CYTOXAN™); alkyl sulfonates such as busulfan, improsulfan and piposulfan; aziridines such as benzodopa, carboquone, meturedopa, and uredopa; ethylenimines and methylamelamines including altretamine, triethylenemelamine,

triethylenephosphoramidate, triethylenethiophosphoramidate and trimethylololmelamine; acetogenins (especially bullatacin and bullatacinone); a camptothecin (including synthetic analogue topotecan); bryostatin; callistatin; CC-1065 (including its adozelesin, carzelesin and bizelesin synthetic analogues); cryptophycins (particularly cryptophycin 1 and cryptophycin 8); dolastatin; duocarmycin (including the synthetic analogues, KW-2189 and CBI-TMI); eleutherobin; pancratistatin; a sarcodictyin; spongistatin; nitrogen mustards such as chlorambucil, chlornaphazine, cholophosphamide, estramustine, ifosfamide, mechlorethamine, mechlorethamine oxide hydrochloride, melphalan, novembichin, phenesterine, prednimustine, trofosfamide, uracil mustard; nitrosoureas such as carmustine, chlorozotocin, foremustine, lomustine, nimustine, ranimustine; antibiotics such as the enediyne antibiotics (e.g. calicheamicin, especially calicheamicin gammaII and calicheamicin phiII, see, e.g., Agnew, Chem. Intl. Ed. Engl., 33: 183-186 (1994); dynemicin, including dynemicin A; bisphosphonates, such as clodronate; an esperamicin; as well as neocarzinostatin chromophore and related chromoprotein enediyne antibiotic chromomophores), aclacinomysins, actinomycin, authramycin, azaserine, bleomycins, cactinomycin, carabacin, carminomycin, carzinophilin, chromomycins, dactinomycin, daunorubicin, detorubicin, 6-diazo-5-oxo-L-norleucine, doxorubicin (Adramycin™) (including morpholino-doxorubicin, cyanomorpholino-doxorubicin, 2-pyrrolino-doxorubicin and deoxydoxorubicin), epirubicin, esorubicin, idarubicin, marcellomycin, mitomycins such as mitomycin C, mycophenolic acid, nogalamycin, olivomycins, peplomycin, potfiromycin, puromycin, quelamycin, rodorubicin, streptonigrin, streptozocin, tubercidin, ubenimex, zinostatin, zorubicin; anti-metabolites such as methotrexate and 5-fluorouracil (5-FU); folic acid analogues such as demopterin, methotrexate, pteropterin, trimetrexate; purine analogs such as fludarabine, 6-mercaptopurine, thiamiprine, thioguanine; pyrimidine analogues such as ancitabine, azacitidine, 6-azauridine, carmofur, cytarabine, dideoxyuridine, doxifluridine, enocitabine, floxuridine; androgens such as calusterone, dromostanolone propionate, epitostanol, mepitostane, testolactone; anti-adrenals such as aminoglutethimide, mitotane, trilostane; folic acid replenisher such as frolinic acid; aceglatone; aldophosphamide glycoside; aminolevulinic acid; eniluracil; amsacrine; bestabucil; bisantrene; edatraxate; defofamine; demecolcine; diaziquone; elfornithine; elliptinium acetate; an epothilone; etoglucid; gallium nitrate; hydroxyurea; lentinan; lonidamine; maytansinoids such as maytansine and ansamitocins; mitoguazone; mitoxantrone; mopidamol; nitracrine; pentostatin; phenamet; pirarubicin; losoxantrone; podophyllinic acid; 2-ethylhydrazide; procarbazine; PSK®; razoxane; rhizoxin; sizofiran; spirogermanium; tenuazonic acid; triaziquone; 2,2',2''-trichlorotriethylamine; trichothecenes (especially T-2

toxin, verracurin A, roridin A and anguidine); urethane; vindesine; dacarbazine; mannomustine; mitobronitol; mitolactol; pipobroman; gacytosine; arabinoside ("Ara-C"); cyclophosphamide; thiopeta; taxoids, e.g. paclitaxel (TAXOL®, Bristol Meyers Squibb Oncology, Princeton, NJ) and docetaxel (TAXOTERE®, Rhone-Poulenc Rorer, Antony, France); chlorambucil; gemcitabine (Gemzar™); 6-thioguanine; mercaptopurine; methotrexate; platinum analogs such as cisplatin and carboplatin; vinblastine; platinum; etoposide (VP-16); ifosfamide; mitroxantrone; vancristine; vinorelbine (Navelbine™); novantrone; teniposide; edatrexate; daunomycin; aminopterin; xeoloda; ibandronate; CPT-11; topoisomerase inhibitor RFS 2000; difluoromethylornithine (DMFO); retinoids such as retinoic acid; capecitabine; and pharmaceutically acceptable salts, acids or derivatives of any of the above. Also included in the definition of "chemotherapeutic agent" are anti-hormonal agents that act to regulate or inhibit hormone action on tumors such as anti-estrogens and selective estrogen receptor modulators (SERMs), including, for example, tamoxifen (including Nolvadex™), raloxifene, droloxifene, 4-hydroxytamoxifen, trioxifene, keoxifene, LY117018, onapristone, and toremifene (Fareston™); inhibitors of the enzyme aromatase, which regulates estrogen production in the adrenal glands, such as, for example, 4(5)-imidazoles, aminoglutethimide, megestrol acetate (Megace™), exemestane, formestane, fadrozole, vorozole (Rivisor™), letrozole (Femara™), and anastrozole (Arimidex™); and anti-androgens such as flutamide, nilutamide, bicalutamide, leuprolide, and goserelin; and pharmaceutically acceptable salts, acids or derivatives of any of the above.

**[0084]** The term "antineoplastic" agent, drug or compound is meant to refer to any agent, including any chemotherapeutic agent, biological response modifier (including without limitation (i) proteinaceous, i.e. peptidic, molecules capable of elaborating or altering biological responses and (ii) non-proteinaceous, i.e. non-peptidic, molecules capable of elaborating or altering biological responses), cytotoxic agent, or cytostatic agent, that reduces proliferation of a neoplastic cell.

**[0085]** The term "biological response modifier" refers to any proteinaceous (i.e., peptidic) molecule or any non-proteinaceous (i.e., non-peptidic) molecule capable of elaborating or altering a biological response relevant to the treatment of cancer. Examples of biological response modifiers include antagonists of tumor-associated antigens, such as anti-tumor antigen antibodies, antagonists of cellular receptors capable of inducing cell proliferation, agonists of cellular receptors capable of inducing apoptosis, such as Apo-2 ligands, Type I interferon receptor agonists, such as interferon- $\alpha$  molecules and interferon- $\beta$  molecules, Type II interferon receptor agonists, such as interferon- $\gamma$  molecules, Type III interferon receptor



agonists, such as IL-28A, IL-28B, and IL-29, antagonists of inflammatory cytokines, including tumor necrosis factor (TNF) antagonists, such as anti-TNF antibodies (e.g. REMICADE™ anti-TNF monoclonal antibody) and soluble TNF receptor (e.g. ENBREL™ TNF receptor-Ig immunoadhesin), growth factor cytokines, such as hematopoietic cytokines, including erythropoietins, such as EPOGEN™ epoetin-alfa, granulocyte colony stimulating factors (G-CSFs), such as NEUPOGEN™ filgrastim, granulocyte-macrophage colony stimulating factors (GM-CSFs), and thrombopoietins, lymphocyte growth factor cytokines, such as interleukin-2, and antagonists of growth factor cytokines, including antagonists of angiogenic factors, e.g. vascular endothelial cell growth factor (VEGF) antagonists, such as AVASTIN™ bevacizumab (anti-VEGF monoclonal antibody).

[0086] As used herein, the term “HCV enzyme inhibitor” refers to any agent that inhibits an enzymatic activity of an enzyme encoded by HCV. The term “HCV enzyme inhibitor” includes, but is not limited to, agents that inhibit HCV NS3 protease activity; agents that inhibit HCV NS3 helicase activity; and agents that inhibit HCV NS5B RNA-dependent RNA polymerase activity.

[0087] As used herein, the terms “HCV NS3 protease inhibitor” and “NS3 protease inhibitor” refer to any agent that inhibits the protease activity of HCV NS3/NS4A complex. Unless otherwise specifically stated, the term “NS3 inhibitor” is used interchangeably with the terms “HCV NS3 protease inhibitor” and “NS3 protease inhibitor.”

[0088] As used herein, the terms “HCV NS5B inhibitor,” “NS5B inhibitor,” “HCV NS5B RNA-dependent RNA polymerase inhibitor,” “HCV RDRP inhibitor,” and “RDRP inhibitor,” refer to any agent that inhibits HCV NS5B RNA-dependent RNA polymerase activity.

[0089] Before the present invention is further described, it is to be understood that this invention is not limited to particular embodiments described, as such may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting, since the scope of the present invention will be limited only by the appended claims.

[0090] Where a range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit unless the context clearly dictates otherwise, between the upper and lower limit of that range and any other stated or intervening value in that stated range, is encompassed within the invention. The upper and lower limits of these smaller ranges may independently be included in the smaller ranges, and are also encompassed within the invention, subject to any specifically excluded limit in the stated range. Where the stated

range includes one or both of the limits, ranges excluding either or both of those included limits are also included in the invention.

[0091] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the present invention, the preferred methods and materials are now described. All publications mentioned herein are incorporated herein by reference to disclose and describe the methods or materials in connection with which the publications are cited.

[0092] It must be noted that as used herein and in the appended claims, the singular forms “a”, “and”, and “the” include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to “a protease-resistant or protease-resistant, hyperglycosylated polypeptide variant” includes a plurality of such polypeptide variants and reference to “the oral formulation” includes reference to one or more oral formulations and equivalents thereof known to those skilled in the art, and so forth.

[0093] The publications discussed herein are provided solely for their disclosure prior to the filing date of the present application. Nothing herein is to be construed as an admission that the present invention is not entitled to antedate such publication by virtue of prior invention. Further, the dates of publication provided may be different from the actual publication dates which may need to be independently confirmed.

#### DETAILED DESCRIPTION OF THE INVENTION

[0094] The present invention provides oral pharmaceutical compositions comprising a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic. The known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant contains (1) a carbohydrate moiety covalently linked to at least one non-native glycosylation site not found in the parent protein therapeutic or (2) a carbohydrate moiety covalently linked to at least one native glycosylation site found but not glycosylated in the parent protein therapeutic. In addition, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent protein therapeutic, and thus exhibits increased protease resistance compared to the parent protein therapeutic.

[0095] The present invention further provides therapeutic methods for treating a disease in a patient involving orally administering to the patient a known protease-resistant or protease-

resistant, hyperglycosylated polypeptide variant in an oral dosage form and at a dosing interval that delivers more drug (on a mole basis) per dose and at least as many doses per unit of time as that received by the patient in a method proven to be effective for treating the disease by subcutaneous bolus injection of the parent polypeptide in a parenteral dosage form.

[0096] The present invention further provides synthetic Type I interferon receptor polypeptide agonists that contain one or more glycosylation sites; and compositions, including pharmaceutical compositions, comprising the agonists. The present invention further provides nucleic acids comprising nucleotide sequences encoding subject polypeptide agonists; and host cells comprising subject nucleic acids. The present invention further provides containers and kits comprising a subject polypeptide agonist.

[0097] A subject synthetic Type I interferon receptor polypeptide agonist comprises a hybrid or consensus Type I interferon receptor polypeptide agonist comprising at least one glycosylation site. The glycosylation site(s) provides a site for attachment of a carbohydrate moiety on the subject synthetic polypeptide agonist, such that when the subject synthetic polypeptide agonist is produced in a eukaryotic cell capable of glycosylation, the subject synthetic polypeptide agonist is glycosylated. The glycosylation confers one or more advantages on the subject synthetic polypeptide agonist, relative to a parent Type I interferon receptor polypeptide agonist, or compared to a naturally-occurring Type I interferon receptor polypeptide agonist. Such advantages include increased serum half-life; reduced immunogenicity; increased functional *in vivo* half-life; reduced degradation by gastrointestinal tract conditions; and increased rate of absorption by gut epithelial cells. An increased rate of absorption by gut epithelial cells and reduced degradation by gastrointestinal tract conditions is important for enteral (e.g., oral) formulations of a subject synthetic Type I interferon receptor polypeptide agonist.

[0098] Subject synthetic Type I interferon receptor polypeptide agonists are useful for treating various disorders, including viral infections, fibrotic disorders, and proliferative disorders. Accordingly, the present invention further provides methods of treating viral infections, methods of treating fibrotic disorders, and methods of treating proliferative disorders, the methods generally involving administering to an individual in need thereof an effective amount of a subject synthetic polypeptide agonist. In some embodiments, a subject treatment method further involves administration of at least one additional therapeutic agent to treat the viral infection, fibrotic disorder, or proliferative disorder. In some embodiments, a subject treatment method further involves administering at least one side effect management agent to reduce side effects induced by one or more of the therapeutic agents.

[0099] In another aspect, the synthetic Type I interferon receptor polypeptide agonists of the invention find utility as reagents for detection and isolation of Type I interferon receptor, such as detection of Type I interferon receptor expression in various cell types and tissues, including the determination of Type I interferon receptor density and distribution in cell populations, and cell sorting based on Type I interferon receptor expression. In yet another aspect, the subject synthetic Type I interferon receptor agonists are useful for the development of agents with Type I interferon receptor binding or activation patterns similar to those of the subject synthetic Type I interferon receptor agonists. The synthetic Type I interferon receptor agonists of the invention can be used in Type I interferon receptor signal transduction assays to screen for small molecule agonists or antagonists of Type I interferon receptor signaling.

#### POLYPEPTIDE VARIANTS

[00100] The present invention relates to protease-resistant or protease-resistant, hyperglycosylated polypeptide variants. The protease-resistant or protease-resistant, hyperglycosylated polypeptide variants comprise at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent protein therapeutic, and thus exhibit increased protease resistance compared to the parent protein therapeutic.

[00101] A protease cleavage site that is found in a parent protein therapeutic, and that is mutated in a protease-resistant or protease-resistant, hyperglycosylated polypeptide variant, such that the site is no longer cleaved, or exhibits greater resistance to cleavage (i.e., is a worse substrate than the native site for proteolytic processing) by the protease that cleaves the protease cleavage site in the parent protein, is referred to herein as a "mutated protease cleavage site" or a "mutant cleavage site." A protease cleavage site that is found in a parent protein therapeutic is referred to herein as a "native protease cleavage site."

[00102] In addition, a protease-resistant or protease-resistant, hyperglycosylated polypeptide variant includes (1) a carbohydrate moiety covalently attached to at least one non-native glycosylation site not found in a parent protein therapeutic or (2) a carbohydrate moiety covalently attached to at least one native glycosylation site found but not glycosylated in a parent protein therapeutic. A glycosylation site that is not found in a parent protein therapeutic is referred to herein as a "non-native glycosylation site." A glycosylation site that is found in but not glycosylated in a parent protein therapeutic is referred to herein as a "native glycosylation site." Thus, a protease-resistant or protease-resistant, hyperglycosylated polypeptide variant includes (1) a carbohydrate moiety covalently linked to the at least one non-native glycosylation site and/or (2) a carbohydrate moiety covalently linked to the at least one native glycosylation site. A protease-resistant or protease-resistant, hyperglycosylated

polypeptide variant that includes (1) a carbohydrate moiety covalently linked to a non-native glycosylation site or (2) a carbohydrate moiety covalently linked to a native glycosylation site, and that comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in a parent protein therapeutic, is referred to herein as a “protease-resistant or protease-resistant, hyperglycosylated polypeptide variant.”

[00103] A “known” protease-resistant or protease-resistant, hyperglycosylated polypeptide variant means any protease-resistant or protease-resistant, hyperglycosylated polypeptide variant presently in existence or hereafter created that (1) retains a desired pharmacologic activity of a parent protein therapeutic and (2) exhibits a longer serum half-life or greater area under the curve of drug concentration in serum as a function of time (AUC) compared to that exhibited by the parent protein therapeutic when administered to a patient in a similar form and at a similar dose, dosing frequency and route of administration. The present invention provides compositions, including oral pharmaceutical compositions, comprising the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variants.

[00104] A known hyperglycosylated, protease-resistant polypeptide variant is provided in a formulation suitable for oral delivery. The parent protein therapeutic is ordinarily administered in an immediate release formulation suitable for subcutaneous bolus injection. Typically, the oral dosage form of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant contains a first number of moles; and the parent protein therapeutic is in a parenteral dosage form that contains a second number of moles. In general, the first number of moles is greater than the second number of moles. Nevertheless, a protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in the oral dosage form is released over a period of time that is no longer than the dosing interval used in the administration of the parent protein therapeutic in a regimen proven to be effective for the treatment of a disease in a patient.

[00105] The parent protein therapeutic is typically in a parenteral dosage form administered by subcutaneous bolus injection, which provides a “depot” effect, slowly releasing the protein therapeutic into the bloodstream by diffusion of drug away from the tissues surrounding the injection site.

[00106] A subject method of the invention replaces the subcutaneous bolus injection “depot” effect with a comparable pharmacokinetic profile achieved by oral delivery of a longer-acting agent (a known hyperglycosylated, protease-resistant polypeptide variant with a greater serum half-life and/or AUC than its parent protein) free of an extended release or depot formulation. That is, the time required for release of the first number of moles of the known

hyperglycosylated, protease-resistant polypeptide variant, when administered orally, is no greater than the period of time between doses of the parent protein therapeutic when administered by subcutaneous bolus injection in a method that is proven to be effective for treatment of the disease. Thus, in some embodiments, a known hyperglycosylated, protease-resistant polypeptide variant is administered at least as frequently, or in many cases more frequently, and at higher dosage (on a mole basis) than the parent protein therapeutic.

#### Structural features

[00107] A protease-resistant or protease-resistant, hyperglycosylated polypeptide variant has an amino acid sequence that comprises one or more mutated protease cleavage sites in place of a native protease cleavage site(s) found in a corresponding parent protein therapeutic; and has an amino acid sequence that comprises (1) one or more non-native glycosylation sites and/or (2) one or more native glycosylation sites. Thus, e.g., a desired polypeptide variant has an amino acid sequence that comprises one or more mutated protease cleavage sites in place of a native protease cleavage site(s) found in a parent protein therapeutic; and has an amino acid sequence that comprises one or more glycosylation sites not found in the parent protein therapeutic or found but not glycosylated in the parent protein therapeutic. A parent protein therapeutic is in some embodiments a corresponding naturally-occurring polypeptide. In other embodiments, a parent protein therapeutic is a non-naturally occurring polypeptide (e.g., a synthetic polypeptide, a hybrid polypeptide, a consensus polypeptide, a fusion polypeptide, a recombinant polypeptide, or other variant of a naturally-occurring polypeptide). As used herein, the terms “polypeptide variant” and “variant polypeptide” both refer to any polypeptide that comprises one or more mutated protease cleavage sites in place of a native protease cleavage sites(s) found in a parent protein therapeutic; and that comprises (1) one or more glycosylation sites not found in the parent protein therapeutic or (2) one or more glycosylation sites found but not glycosylated in the parent protein therapeutic.

[00108] Non-native and native glycosylation sites include *N*-linked glycosylation sites, and *O*-linked glycosylation sites. *N*-linked glycosylation sites include, e.g., Asn-X-Ser/Thr, where the asparagine residue provides a site for *N*-linked glycosylation, and where X is any amino acid. *O*-linked glycosylation sites include at least one serine or threonine residue. A number of *O*-linked glycosylation sites are known in the art and have been reported in the literature. See, e.g., Ten Hagen et al. (1999) *J. Biol. Chem.* 274(39):27867-74; Hanisch et al. (2001) *Glycobiology* 11:731-740; and Ten Hagen et al. (2003) *Glycobiology* 13:1R-16R.

[00109] In all embodiments, a polypeptide variant is hyperglycosylated, e.g., a polypeptide variant comprises (1) a carbohydrate moiety covalently linked to a non-native glycosylation

site and/or (2) a carbohydrate moiety covalently linked to a native glycosylation site. In many embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a carbohydrate moiety covalently linked to a native glycosylation site; and a carbohydrate moiety covalently linked to a non-native glycosylation site. In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises *O*-linked glycosylation. In other embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises *N*-linked glycosylation. In other embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises both *O*-linked and *N*-linked glycosylation.

[00110] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises one, two, three, four, or five carbohydrate moieties, each linked to different glycosylation sites. In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is glycosylated at a non-native glycosylation site. In some of these embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is glycosylated at a single non-native glycosylation site. In other embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is glycosylated at more than one non-native glycosylation site, e.g., the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is glycosylated at two, three, or four non-native glycosylation sites.

[00111] In other embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is glycosylated at a native glycosylation site. In some of these embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is glycosylated at a single native glycosylation site. In other embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is glycosylated at more than one native glycosylation site, e.g., the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is glycosylated at two, three, or four native glycosylation sites.

[00112] In other embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is glycosylated at both a native glycosylation site(s) and a non-native glycosylation site(s).

[00113] A known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant can comprise at least one additional carbohydrate moiety not found in a parent protein therapeutic when each is synthesized in a eukaryotic cell that is capable of *N*- and/or *O*-linked protein glycosylation. Thus, e.g., compared to a parent protein therapeutic, a known protease-

resistant or protease-resistant, hyperglycosylated polypeptide variant can comprise at least one, at least two, at least three, or at least four, or more, additional carbohydrate moieties. For example, where a parent protein therapeutic has one covalently linked carbohydrate moiety, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant can have two, three, four, or more, covalently linked carbohydrate moieties. In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant lacks a carbohydrate moiety covalently linked to a non-native glycosylation site; and has instead at least one, at least two, at least three, or at least four, or more, additional carbohydrate moieties attached to native glycosylation sites. In other embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant lacks a carbohydrate moiety covalently linked to a native glycosylation site; and has instead at least two, at least three, or at least four, or more, carbohydrate moieties attached to non-native glycosylation sites.

#### Glycosylated Type I Interferons

[00114] A subject synthetic Type I interferon receptor polypeptide agonist can have a consensus or hybrid Type I interferon receptor polypeptide agonist amino acid sequence that comprises one or more non-native glycosylation sites. Thus, e.g., a subject synthetic Type I interferon receptor polypeptide agonist can have an amino acid sequence that comprises one or more glycosylation sites not found in a naturally-occurring Type I interferon receptor polypeptide agonist, e.g., not found in any known naturally occurring IFN- $\alpha$ , IFN- $\beta$ , or IFN- $\omega$ . As used herein, the term “non-native glycosylation site” is defined as a glycosylation site located at a position in a synthetic Type I interferon receptor polypeptide agonist amino acid sequence, for which glycosylation site/position there is no homologous glycosylation site/position that exists in a naturally-occurring Type I interferon receptor polypeptide agonist amino acid sequence.

[00115] Alternatively, a subject synthetic Type I interferon receptor polypeptide agonist can have a consensus or hybrid Type I interferon receptor polypeptide agonist amino acid sequence that comprises one or more naturally-occurring or native glycosylation sites. As used herein, the term “native glycosylation site” is defined as a glycosylation site located at a position in a synthetic Type I interferon receptor polypeptide agonist amino acid sequence, for which glycosylation site/position there is a homologous glycosylation site/position that exists in at least one naturally-occurring Type I interferon receptor polypeptide agonist amino acid sequence.

[00116] As used herein, the term “synthetic Type I interferon receptor polypeptide agonist” is defined as any consensus or hybrid Type I interferon polypeptide agonist that comprises one or more glycosylation sites. Thus, a “synthetic Type I interferon receptor polypeptide agonist”



encompasses any hybrid or consensus Type I interferon receptor polypeptide agonist that comprises one or more glycosylation sites, including any hybrid or consensus Type I interferon receptor polypeptide agonist that comprises one or more native glycosylation sites and/or one or more non-native glycosylation sites.

[00117] A "parent Type I interferon receptor polypeptide agonist" is a Type I interferon receptor polypeptide agonist that serves as a reference point for comparison. In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises at least one additional glycosylation site not found in a parent Type I interferon receptor polypeptide agonist. For example, in some embodiments, a parent Type I interferon receptor polypeptide agonist is Infergen® consensus IFN- $\alpha$  (InterMune, Inc., Brisbane, Calif.). As shown in Figure 25, a subject synthetic Type I interferon receptor polypeptide agonist comprises one or more glycosylation sites not found in the parent Infergen® consensus IFN- $\alpha$ .

[00118] A subject synthetic Type I interferon receptor polypeptide agonist has a length of from about 150 amino acids to about 200 amino acids, e.g., from about 150 amino acids to about 155 amino acids, from about 155 amino acids to about 160 amino acids, from about 160 amino acids to about 165 amino acids, from about 165 amino acids to about 170 amino acids, from about 170 amino acids to about 175 amino acids, from about 175 amino acids to about 180 amino acids, from about 180 amino acids to about 185 amino acids, from about 185 amino acids to about 190 amino acids, from about 190 amino acids to about 195 amino acids, or from about 195 amino acids to about 200 amino acids.

[00119] In some embodiments, the amino acid sequence of a naturally-occurring Type I interferon receptor polypeptide agonist is modified to include at least one non-native glycosylation site. As one non-limiting example, where a naturally occurring Type I interferon receptor polypeptide agonist comprises the amino acid sequence KDSS, the KDSS sequence is modified to KNSS. As another non-limiting example, where a naturally occurring Type I interferon receptor polypeptide agonist comprises the amino acid sequence WDET, the WDET sequence is modified to WNET. As another non-limiting example, where a naturally occurring Type I interferon receptor polypeptide agonist comprises the amino acid sequence VEET, the VEET sequence is modified to VTET. As another non-limiting example, where a naturally occurring Type I interferon receptor polypeptide agonist comprises the amino acid sequence VEET, the VEET sequence is modified to VNET.

[00120] In many embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is glycosylated. In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises O-linked glycosylation. In other embodiments, a subject

synthetic Type I interferon receptor polypeptide agonist comprises N-linked glycosylation. In other embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises both O-linked and N-linked glycosylation.

[00121] In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is glycosylated at a non-native glycosylation site. In some of these embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is glycosylated at a single non-native glycosylation site. In other embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is glycosylated at more than one non-native glycosylation site, e.g., the subject synthetic Type I interferon receptor polypeptide agonist is glycosylated at two, three, or four non-native glycosylation sites.

[00122] In other embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is glycosylated at a native glycosylation site. In some of these embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is glycosylated at a single native glycosylation site. In other embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is glycosylated at more than one native glycosylation site, e.g., the subject synthetic Type I interferon receptor polypeptide agonist is glycosylated at two, three, or four native glycosylation sites.

[00123] In other embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is glycosylated at both a native glycosylation site(s) and a non-native glycosylation site(s).

[00124] Whether a subject synthetic Type I interferon receptor polypeptide agonist comprises N-linked and/or O-linked glycosylation is readily determined using standard techniques. See, e.g., "Techniques in Glycobiology" R. Townsend and A. Hotchkiss, eds. (1997) Marcel Dekker; and "Glycoanalysis Protocols (Methods in Molecular Biology, Vol. 76)" E. Hounsell, ed. (1998) Humana Press. The change in electrophoretic mobility of a protein before and after treatment with chemical or enzymatic deglycosylation (e.g., using endoglycosidases and/or exoglycosidases) is routinely used to determine the glycosylation status of a protein. Enzymatic deglycosylation can be carried out using any of a variety of enzymes, including, but not limited to, peptide-N4-(N-acetyl- $\beta$ -D-glucosaminyl) asparagine amidase (PNGase F); endoglycosidase F1, endoglycosidase F2, endoglycosidase F3,  $\alpha$ (2 $\rightarrow$ 3,6,8,9) neuraminidase, and the like. For example, sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) analysis of the protein, either pre-treated with PNGase F or untreated with PNGaseF, is conducted. A marked decrease in band width and change in migration position after treatment with PNGaseF is considered diagnostic of N-linked glycosylation. The carbohydrate content

of a glycosylated protein can also be detected using lectin analysis of protein blots (e.g., proteins separated by SDS-PAGE and transferred to a support, such as a nylon membrane). Lectins, carbohydrate-binding proteins from various plant tissues, have both high affinity and narrow specificity for a wide range of defined sugar epitopes found on glycoprotein glycans. Cummings (1994) *Methods in Enzymol.* 230:66-86. Lectins can be detectably labeled (either directly or indirectly), allowing detection of binding of lectins to carbohydrates on glycosylated proteins. For example, when conjugated with biotin or digoxigenin, a lectin bound to a glycosylated protein can be easily identified on membrane blots through a reaction utilizing avidin or anti-digoxigenin antibodies conjugated with an enzyme such as alkaline phosphatase,  $\beta$ -galactosidase, luciferase, or horse radish peroxidase, to yield a detectable product. Screening with a panel of lectins with well-defined specificity provides considerable information about a glycoprotein's carbohydrate complement.

*Consensus Type I interferon receptor polypeptide agonists with non-native glycosylation site(s)*

[00125] In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises a consensus amino acid sequence and at least one non-native glycosylation site. In other embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises a consensus amino acid sequence and at least one native glycosylation site.

[00126] A consensus sequence is derived by aligning three or more amino acid sequences, and identifying amino acids that are shared by at least two of the sequences. In some embodiments, a synthetic Type I interferon receptor polypeptide agonist comprises a consensus sequence derived from determining a consensus sequence of naturally occurring human IFN- $\alpha$ 2b, naturally-occurring human IFN- $\alpha$ 14, and naturally-occurring human IFN- $\beta$ 1. In other embodiments, a synthetic Type I interferon receptor polypeptide agonist comprises a consensus sequence derived from determining a consensus sequence of naturally occurring human IFN- $\alpha$ 2b, naturally-occurring human IFN- $\alpha$ 14, and naturally-occurring human IFN- $\omega$ 1. In other embodiments, a synthetic Type I interferon receptor polypeptide agonist comprises a consensus sequence derived from determining a consensus sequence of naturally occurring human IFN- $\alpha$ 2b, naturally-occurring human IFN- $\beta$ 1, and naturally-occurring human IFN- $\omega$ 1. In other embodiments, a synthetic Type I interferon receptor polypeptide agonist comprises a consensus sequence derived from determining a consensus sequence of naturally occurring human IFN- $\alpha$ 14, naturally-occurring human IFN- $\beta$ 1, and naturally-occurring human IFN- $\omega$ 1. In other embodiments, a synthetic Type I interferon receptor polypeptide agonist comprises a consensus sequence derived from determining a consensus sequence of naturally occurring human IFN- $\alpha$ 2b, naturally-occurring human IFN- $\alpha$ 14, naturally-occurring human IFN- $\beta$ 1, and naturally-

occurring human IFN- $\omega$ 1. In other embodiments, the comparison further comprises including in the comparison the amino acid sequence of Infergen® consensus IFN- $\alpha$ .

[00127] In some of these embodiments, the subject synthetic Type I interferon receptor polypeptide agonist is a consensus sequence containing one or more glycosylation sites originating from one or more of the parent Type I interferon receptor polypeptide agonist amino acid sequences used to derive the consensus sequence. In additional embodiments, the consensus sequence is further modified to incorporate at least one non-native glycosylation site.

[00128] In one embodiment, the subject synthetic Type I interferon receptor polypeptide agonist comprises an amino acid sequence corresponding to the majority sequence depicted in Fig. 24 (SEQ ID NO:\*\*), further modified to incorporate at least one non-native glycosylation site.

[00129] In another embodiment, the subject synthetic Type I interferon receptor polypeptide agonist comprises an amino acid sequence corresponding to the majority sequence depicted in Fig. 24 (SEQ ID NO:\*\*), further modified to incorporate at least one glycosylation site from the group of the VTET glycosylation site of IFN- $\alpha$ 2b, the KNSS glycosylation site of IFN- $\alpha$ 14, the WNET glycosylation site of IFN- $\beta$ 1, and the WNMT glycosylation site of IFN- $\omega$ 1. In other embodiments, the majority sequence is additionally modified to incorporate one or more non-native glycosylation sites.

[00130] In other embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is obtained from a consensus sequence that does not have a glycosylation site originating from a parent Type I interferon receptor polypeptide agonist. In these embodiments, the consensus sequence is then further modified to include at least one non-native glycosylation site in order to obtain the subject synthetic Type I interferon receptor polypeptide agonist. For example, in some embodiments, where the consensus sequence includes KDSS, the KDSS sequence is modified to KNSS or KNST. As another non-limiting example, where the consensus sequence includes WDET, the WDET sequence is modified to WNET or WNES. As another non-limiting example, where the consensus sequence includes VEET, the VEET sequence is modified to VTET, VNES or VNET.

[00131] In particular embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises the amino acid sequence identified as "majority" in Figure 24, and further comprises one or more of the following modifications: KDSS modified to KNST; WDET modified to WNES; VEET modified to VNES or VNET.

[00132] In some particular embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises an amino acid sequence as set forth in any one of SEQ ID NOs:\*, as set forth in Figure 25.

[00133] In one embodiment, a subject synthetic Type I interferon receptor polypeptide agonist comprises an amino acid sequence corresponding to the majority sequence depicted in Fig. 28 (SEQ ID NO:\*\*), further modified to incorporate at least one non-native glycosylation site. In some embodiments, a subject Type I interferon receptor polypeptide agonist comprises an amino acid sequence as set forth in any one of SEQ ID NOs:\*, as set forth in Figure 28.

[00134] In one embodiment, a subject synthetic Type I interferon receptor polypeptide agonist comprises an amino acid sequence corresponding to the majority sequence depicted in Fig. 29 (SEQ ID NO:\*), further modified to incorporate at least one non-native glycosylation site. In some embodiments, a subject Type I interferon receptor polypeptide agonist comprises an amino acid sequence as set forth in any one of SEQ ID NOs:\*, as set forth in Figure 29.

*Hybrid Type I interferon receptor polypeptide agonists with non-native glycosylation site(s)*

[00135] In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises a hybrid Type I interferon receptor polypeptide agonist with one or more glycosylation sites. In other embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises a hybrid type I interferon receptor polypeptide agonist with one or more glycosylation sites not found in any naturally occurring Type I interferon receptor polypeptide agonist. As used herein, a "hybrid Type I interferon receptor polypeptide agonist" is a polypeptide having an amino acid sequence comprising discrete sub-sequences corresponding in amino acid identity and number to sub-sequences of different, naturally occurring Type I interferon receptor polypeptide agonists, wherein the amino acid sequence of the subject synthetic polypeptide agonist differs from that of any naturally-occurring Type I interferon receptor polypeptide agonist. In some embodiments, the discrete sub-sequences are selected from IFN- $\alpha$ 2b, IFN- $\alpha$ 14, IFN- $\beta$ 1, and IFN- $\omega$ , and the amino acid sequence of the polypeptide agonist differs from the amino acid sequence of naturally occurring Type I interferon receptor polypeptide agonists IFN- $\alpha$ 2b, IFN- $\alpha$ 14, IFN- $\beta$ 1, and IFN- $\omega$ .

[00136] In other embodiments, the discrete sub-sequences can be selected from IFN- $\alpha$ 2b, IFN- $\alpha$ 14, IFN- $\beta$ 1, Infergen® consensus IFN- $\alpha$ , and IFN- $\omega$ , and the amino acid sequence of the polypeptide agonist differs from each of the amino acid sequences of the Type I interferon receptor polypeptide agonists IFN- $\alpha$ 2b, IFN- $\alpha$ 14, IFN- $\beta$ 1, Infergen® consensus IFN- $\alpha$ , and IFN- $\omega$ , respectively.

[00137] In some of these embodiments, the subject synthetic Type I interferon receptor polypeptide agonist is a hybrid Type I interferon receptor polypeptide agonist amino acid sequence containing one or more glycosylation sites originating from one or more of the parental Type I interferon receptor polypeptide agonist amino acid sequences used to derive the hybrid sequence. In additional embodiments, the hybrid sequence is further modified to incorporate at least one additional non-native glycosylation site (in addition to any non-native glycosylation site(s) originating from a parental Type I interferon receptor polypeptide agonist amino acid sequence).

[00138] It will be appreciated that the synthetic Type I interferon receptor polypeptide agonists of the invention include hybrid Type I interferon polypeptide agonists formed by substituting one or more amino acid residues in a parental IFN- $\alpha$  amino acid sequence with the amino acid residue or residues that form a native glycosylation site at a homologous position in another parental IFN- $\alpha$  amino acid sequence.

[00139] In one non-limiting example, the subject synthetic Type I interferon receptor polypeptide agonist is a hybrid Type I interferon receptor polypeptide agonist having a hybrid sequence formed by substituting KNSS for the native KDSS residues in the sequence of interferon alfa-2a or in the sequence of interferon alfa-2b. These synthetic Type I receptor polypeptide agonists are referred to herein as IFN- $\alpha$ 2a (D99N) and IFN- $\alpha$ 2b (D99N), respectively, where the amino acid sequence numbering is that shown in Figure 24.

[00140] In another non-limiting example, the subject synthetic Type I interferon receptor polypeptide agonist is a hybrid Type I interferon receptor polypeptide agonist having a hybrid sequence formed by substituting WNET for the native WDET residues in the sequence of interferon alfa-2a or in the sequence of interferon alfa-2b. These synthetic Type I receptor polypeptide agonists are referred to herein as IFN- $\alpha$ 2a (D105N) and IFN- $\alpha$ 2b (D105N), respectively, where the amino acid sequence numbering is that shown in Figure 24.

[00141] In another non-limiting example, the subject synthetic Type I interferon receptor polypeptide agonist is a hybrid Type I interferon receptor polypeptide agonist having a hybrid sequence formed by substituting KNSS and WNET for the native KDSS and WDET residues, respectively, in the sequence of interferon alfa-2a or in the sequence of interferon alfa-2b. These synthetic Type I receptor polypeptide agonists are referred to herein as IFN- $\alpha$ 2a (D99N, D105N) and IFN- $\alpha$ 2b (D99N, D105N), respectively, where the amino acid sequence numbering is that shown in Figure 24.

[00142] In other embodiments, the subject synthetic Type I interferon receptor polypeptide agonist is obtained from a hybrid sequence that does not have any glycosylation site(s)

originating from a parental Type I interferon receptor polypeptide agonist amino acid sequence. In these embodiments, the hybrid sequence is then further modified to include at least one non-native glycosylation site in order to obtain the subject synthetic Type I interferon receptor polypeptide agonist. For example, in some embodiments, where the hybrid sequence includes KDSS, the KDSS sequence is modified to KNSS. As another non-limiting example, where the hybrid sequence includes WDET, the WDET sequence is modified to WNET. As another non-limiting example, where the hybrid sequence includes VEET, the VEET sequence is modified to VTET or VNET.

[00143] In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist comprises, in order from N-terminus to C-terminus, from about 2 to about 90, e.g., from about 2 to about 5, from about 5 to about 7, from about 7 to about 10, from about 10 to about 15, from about 15 to about 20, from about 20 to about 25, from about 25 to about 30, from about 30 to about 35, from about 35 to about 40, from about 40 to about 45, from about 45 to about 50, from about 50 to about 55, from about 55 to about 60, from about 60 to about 65, from about 65 to about 70, from about 75 to about 80, from about 80 to about 85, or from about 85 to about 90 contiguous amino acids of a first Type I interferon receptor polypeptide agonist selected from naturally-occurring human IFN- $\alpha$ 2b (SEQ ID NO:\*), naturally-occurring human IFN- $\alpha$ 14 (SEQ ID NO:\*), naturally occurring human IFN- $\beta$ 1 (SEQ ID NO:\*), and naturally-occurring human IFN- $\omega$ 1 (SEQ ID NO:\*) ; and from about 2 to about 90, e.g., from about 2 to about 5, from about 5 to about 7, from about 7 to about 10, from about 10 to about 15, from about 15 to about 20, from about 20 to about 25, from about 25 to about 30, from about 30 to about 35, from about 35 to about 40, from about 40 to about 45, from about 45 to about 50, from about 50 to about 55, from about 55 to about 60, from about 60 to about 65, from about 65 to about 70, from about 75 to about 80, from about 80 to about 85, or from about 85 to about 90 contiguous amino acids of a second Type I interferon receptor polypeptide agonist selected from naturally-occurring human IFN- $\alpha$ 2b, human IFN- $\alpha$ 14, human IFN- $\beta$ 1, and human IFN- $\omega$ 1, where the first and second Type I interferon receptor polypeptide agonists are different.

[00144] In some embodiments, a subject hybrid synthetic Type I interferon receptor polypeptide agonist further comprises from about 2 to about 90, e.g., from about 2 to about 5, from about 5 to about 7, from about 7 to about 10, from about 10 to about 15, from about 15 to about 20, from about 20 to about 25, from about 25 to about 30, from about 30 to about 35, from about 35 to about 40, from about 40 to about 45, from about 45 to about 50, from about 50 to about 55, from about 55 to about 60, from about 60 to about 65, from about 65 to about 70, from

about 75 to about 80, from about 80 to about 85, or from about 85 to about 90 contiguous amino acids of a third Type I interferon receptor polypeptide agonist selected from naturally-occurring human IFN- $\alpha$ 2b, human IFN- $\alpha$ 14, human IFN- $\beta$ 1, and human IFN- $\omega$ 1, where the third Type I interferon receptor polypeptide agonist is different from the first and second Type I interferon receptor polypeptide agonists.

[00145] In still other embodiments, a subject hybrid synthetic Type I interferon receptor polypeptide agonist further comprises from about 2 to about 90, e.g., from about 2 to about 5, from about 5 to about 7, from about 7 to about 10, from about 10 to about 15, from about 15 to about 20, from about 20 to about 25, from about 25 to about 30, from about 30 to about 35, from about 35 to about 40, from about 40 to about 45, from about 45 to about 50, from about 50 to about 55, from about 55 to about 60, from about 60 to about 65, from about 65 to about 70, from about 75 to about 80, from about 80 to about 85, or from about 85 to about 90 contiguous amino acids of a fourth Type I interferon receptor polypeptide agonist selected from naturally-occurring human IFN- $\alpha$ 2b, human IFN- $\alpha$ 14, human IFN- $\beta$ 1, and human IFN- $\omega$ 1, where the fourth Type I interferon receptor polypeptide agonist is different from the first, second, and third Type I interferon receptor polypeptide agonists.

[00146] In particular embodiments, any of the above-described embodiments of a subject hybrid synthetic Type I interferon receptor polypeptide agonist comprises from about 4 to about 90, e.g., from about 4 to about 7, from about 7 to about 10, from about 10 to about 15, from about 15 to about 20, from about 20 to about 25, from about 25 to about 30, from about 30 to about 35, from about 35 to about 40, from about 40 to about 45, from about 45 to about 50, from about 50 to about 55, from about 55 to about 60, from about 60 to about 65, from about 65 to about 70, from about 75 to about 80, from about 80 to about 85, or from about 85 to about 90 contiguous amino acids of a segment of a human IFN- $\alpha$ 14 polypeptide that includes at least the amino acid sequence KNSS of naturally occurring human IFN- $\alpha$ 14.

[00147] In particular embodiments, any of the above-described embodiments of a subject hybrid synthetic Type I interferon receptor polypeptide agonist comprises from about 4 to about 90, e.g., from about 4 to about 7, from about 7 to about 10, from about 10 to about 15, from about 15 to about 20, from about 20 to about 25, from about 25 to about 30, from about 30 to about 35, from about 35 to about 40, from about 40 to about 45, from about 45 to about 50, from about 50 to about 55, from about 55 to about 60, from about 60 to about 65, from about 65 to about 70, from about 75 to about 80, from about 80 to about 85, or from about 85 to about 90 contiguous amino acids of a segment of a human IFN- $\beta$ 1 polypeptide that includes at least the amino acid sequence WNET of naturally occurring human IFN- $\beta$ 1.



[00148] In particular embodiments, any of the above-described embodiments of a subject hybrid synthetic Type I interferon receptor polypeptide agonist comprises from about 4 to about 90, e.g., from about 4 to about 7, from about 7 to about 10, from about 10 to about 15, from about 15 to about 20, from about 20 to about 25, from about 25 to about 30, from about 30 to about 35, from about 35 to about 40, from about 40 to about 45, from about 45 to about 50, from about 50 to about 55, from about 55 to about 60, from about 60 to about 65, from about 65 to about 70, from about 75 to about 80, from about 80 to about 85, or from about 85 to about 90 contiguous amino acids of a segment of a human IFN- $\omega$ 1 polypeptide that includes at least the amino acid sequence WNMT of naturally occurring human IFN- $\omega$ 1.

[00149] In particular embodiments, any of the above-described embodiments of a subject hybrid synthetic Type I interferon receptor polypeptide agonist comprises from about 4 to about 90, e.g., from about 4 to about 7, from about 7 to about 10, from about 10 to about 15, from about 15 to about 20, from about 20 to about 25, from about 25 to about 30, from about 30 to about 35, from about 35 to about 40, from about 40 to about 45, from about 45 to about 50, from about 50 to about 55, from about 55 to about 60, from about 60 to about 65, from about 65 to about 70, from about 75 to about 80, from about 80 to about 85, or from about 85 to about 90 contiguous amino acids of a segment of a human IFN- $\alpha$ 2b polypeptide that includes at least the amino acid sequence VTET of naturally occurring human IFN- $\alpha$ 2b.

#### Functional features

[00150] A subject synthetic polypeptide is a Type I interferon receptor polypeptide agonist, e.g., a subject synthetic Type I interferon receptor polypeptide agonist binds to and causes signal transduction via the Type I interferon receptor. Whether a subject synthetic Type I interferon receptor polypeptide agonist functions as a Type I interferon receptor agonist can be readily determined using any known assay. Such assays include, an *in vitro* cell-based assay to detect activation of interferon-responsive genes (e.g., using a reporter gene operably linked to a promoter containing one or more interferon responsive elements); and the like. Such assays also include KIRA assays for Type I interferon receptor activation activity as described in the "Diagnostic Uses" section below.

[00151] In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist exhibits one or more of the following activities: antiproliferative activity, anti-viral activity, and anti-fibrotic activity. Whether a subject synthetic Type I interferon receptor polypeptide agonist exhibits anti-viral activity can be readily determined using any known assay, including e.g., an *in vitro* cell-based inhibition of viral replication assay. See, e.g., Patick et al. (1999) *Antimicrobial Agents and Chemotherapy* 43:2444-2450. Whether a subject

synthetic Type I interferon receptor polypeptide agonist exhibits anti-proliferative activity can be readily determined using any known assay, including, e.g., an *in vitro* cell-based inhibition of proliferation assay.

[00152] A subject synthetic Type I interferon receptor polypeptide agonist exhibits one or more of the following properties: increased serum half-life; reduced immunogenicity *in vivo*; increased functional *in vivo* half-life; increased stability; reduced degradation by gastrointestinal tract conditions; and improved water solubility.

[00153] In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist has an increased serum half-life compared to a naturally occurring Type I interferon receptor polypeptide agonist or compared to a parent Type I interferon receptor polypeptide agonist. The term "serum half-life" is used interchangeably herein with the terms "plasma half-life," and "circulating half-life." In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist has a serum half life that is at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, at least about 80%, at least about 90%, at least about 100% (or two-fold), at least about 2.5-fold, at least about 3-fold, at least about 3.5-fold, at least about 4-fold, at least about 4.5-fold, or at least about 5-fold greater than the serum half life of a naturally-occurring Type I interferon receptor polypeptide agonist or parent Type I interferon receptor polypeptide agonist that lacks the non-native glycosylation site. In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist has a serum half life that is at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, at least about 80%, at least about 90%, at least about 100% (or two-fold), at least about 2.5-fold, at least about 3-fold, at least about 3.5-fold, at least about 4-fold, at least about 4.5-fold, or at least about 5-fold greater than the serum half life of a naturally-occurring Type I interferon receptor polypeptide agonist, or a Type I interferon receptor polypeptide agonist that has the same amino acid sequence as a naturally-occurring Type I interferon receptor agonist.

[00154] The serum half-life of a subject synthetic Type I interferon receptor polypeptide agonist is readily determined using well known methods. For example, a subject synthetic Type I interferon receptor polypeptide agonist is detectably labeled, and is administered to an individual (e.g., an experimental non-human animal, or a human subject), and, at various time

points following administration of the agonist, a blood sample is drawn and the amount of detectably labeled synthetic Type I interferon receptor polypeptide agonist in the blood sample is determined.

[00155] In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist exhibits increased resistance to degradation by gastrointestinal tract conditions compared to a naturally occurring Type I interferon receptor polypeptide agonist or compared to a parent Type I interferon receptor polypeptide agonist. In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist exhibits at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, at least about 80%, or at least about 90%, or greater, reduction of degradation in the gastrointestinal tract, compared to the level of degradation of a naturally-occurring Type I interferon receptor polypeptide agonist or parent Type I interferon receptor polypeptide agonist that lacks the non-native glycosylation site(s).

[00156] Whether a subject synthetic Type I interferon receptor polypeptide agonist exhibits increased resistance to degradation by gastrointestinal tract conditions can be readily determined using well-known methods. For example, a subject synthetic Type I interferon receptor polypeptide agonist is contacted *in vitro* with digestive enzymes found in the gastrointestinal tract, and the effect of the enzymes on the structural and functional integrity of the subject synthetic Type I interferon receptor polypeptide agonist determined. An *in vivo* method for determining resistance to degradation by gastrointestinal tract conditions can be used.

[00157] A known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant suitable for use herein is a protease-resistant or protease-resistant, hyperglycosylated variant of a parent protein therapeutic, wherein the parent protein therapeutic is any protein therapeutic that is effective in the treatment of the disease or condition in a patient when administered to the patient. A list of exemplary protein therapeutics is provided below. A known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is effective in the treatment of the same disease or condition in a patient as the corresponding parent protein therapeutic.

Protease Resistant or Protease Resistant, Hyperglycosylated Polypeptide Variants

[00158] A known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a protease-resistant or protease-resistant, hyperglycosylated variant of a protein therapeutic, and is in many embodiments provided in a first unit form. The first unit form can comprise a

first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in an oral pharmaceutical composition. The parent protein therapeutic in many embodiments can be in an immediate release formulation suitable for subcutaneous bolus injection, i.e. a second unit form, where the first number of moles in the first unit form is greater than a second number of moles of the protein therapeutic in the second unit form. For example, the first number of moles can be at least about 5%, at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, or at least about 50%, or at least about 75%, or at least about 100%, or at least about three-fold, or at least about four-fold, or at least about five-fold, or at least about six-fold, or at least about seven-fold, or at least about eight-fold, or at least about nine-fold, or at least about ten-fold, or more, greater than the second number of moles.

[00159] In many embodiments, upon oral administration of the first unit form to a patient, the time required for release of the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is no longer than the period of time that elapses between doses of the parent protein therapeutic when administered in the second unit form by subcutaneous bolus injection at a selected dosing frequency in a therapeutic regimen that is proven to be effective for treating the disease or condition of the patient. Thus, e.g., the time required for release of the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant upon oral administration of the first unit form can be at least about 5%, at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, or at least about 50%, or more, less than the time interval between doses of the parent therapeutic in the second unit form when administered by subcutaneous bolus injection at the selected dosing frequency. In some embodiments, the first unit form is in an immediate release formulation suitable for oral delivery.

[00160] A known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant can be administered by mouth more frequently than the corresponding parent polypeptide is administered by subcutaneous bolus injection. For example, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant can be administered by mouth at least twice as frequently, at least  $2\frac{1}{2}$  times more frequently, at least 2.5 times more frequently, at least three times more frequently, at least 3.5 times more frequently, or at least four times more frequently, or at least five times more frequently, or at least six times more frequently, or more frequently, than the corresponding parent polypeptide is administered by subcutaneous bolus injection. Thus, e.g., where a parent polypeptide therapeutic is administered once weekly, the

corresponding protease-resistant or protease-resistant, hyperglycosylated polypeptide variant can be administered twice weekly, three times weekly, once daily, twice daily, three times daily, or more than three times daily.

[00161] As one non-limiting example, the parent protein therapeutic is IFN- $\gamma$ 1b, and the IFN- $\gamma$ 1b is administered in a unit dosage form suitable for subcutaneous injection at a dosage of  $1 \times 10^6$  International Units (IU)/m<sup>2</sup> (or 50  $\mu$ g/m<sup>2</sup> or  $3.0 \times 10^{-9}$  mol./m<sup>2</sup>) subcutaneously three times per week, for a total weekly dose of 150  $\mu$ g/m<sup>2</sup> (or  $3 \times 10^6$  IU/m<sup>2</sup> or  $9.0 \times 10^{-9}$  mol./m<sup>2</sup>). A desired hyperglycosylated, protease-resistant variant of IFN- $\gamma$ 1b is in a unit dosage form suitable for oral delivery; the known hyperglycosylated, protease-resistant IFN- $\gamma$ 1b variant is administered orally, and more frequently than 3 times per week (e.g., 4 times per week, 5 times per week, 6 times per week, once daily, twice daily, or three times daily); and the total weekly dose of hyperglycosylated, protease-resistant IFN- $\gamma$ 1b variant that is administered is greater than or equal to  $9.0 \times 10^{-9}$  mol./m<sup>2</sup>, e.g., the total weekly dose is from about  $9.0 \times 10^{-9}$  mol./m<sup>2</sup> to about  $1.0 \times 10^{-8}$  mol./m<sup>2</sup>, from about  $1.0 \times 10^{-8}$  mol./m<sup>2</sup> to about  $2.5 \times 10^{-8}$  mol./m<sup>2</sup>, from about  $2.5 \times 10^{-8}$  mol./m<sup>2</sup> to about  $5.0 \times 10^{-8}$  mol./m<sup>2</sup>, or from about  $5.0 \times 10^{-8}$  mol./m<sup>2</sup> to about  $7.5 \times 10^{-8}$  mol./m<sup>2</sup>, or from about  $7.5 \times 10^{-8}$  mol./m<sup>2</sup> to about  $1.0 \times 10^{-7}$  mol./m<sup>2</sup>, or from about  $1.0 \times 10^{-7}$  mol./m<sup>2</sup> to about  $1.0 \times 10^{-6}$  mol./m<sup>2</sup>.

[00162] In another aspect, the total weekly dose of hyperglycosylated, protease-resistant IFN- $\gamma$ 1b variant that is administered is greater than or equal to 500  $\mu$ g, e.g., from about 500  $\mu$ g to about 750  $\mu$ g, from about 750  $\mu$ g to about 1,000  $\mu$ g, from about 1,000  $\mu$ g to about 1,500  $\mu$ g, or from about 1,500  $\mu$ g to about 2,000  $\mu$ g.

[00163] A known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant exhibits increased protease resistance compared to the corresponding parent polypeptide. In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant exhibits resistance to serum proteases that is at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, at least about 80%, at least about 90%, at least about 100% (or two-fold), at least about 2.5-fold, at least about 3-fold, at least about 3.5-fold, at least about 4-fold, at least about 4.5-fold, at least about 5-fold (at least about 5 times), at least about 6-fold, at least about 7-fold, at least about 8-fold, at least about 9-fold, at least about 10-fold, at least about 20-fold, at least about 30-fold, at least about 40-fold, at least about 50-fold, at least about 60-fold, at least about 70-fold, at least about 80-fold, at least about 90-fold, at least about 100-fold, at least about 200-fold, at least about 300-fold, at least

about 400-fold, at least about 500-fold, at least about 600-fold, at least about 700-fold, at least about 800-fold, at least about 900-fold, or at least about 1000-fold, or more, greater than the resistance to serum proteases of the corresponding parent protein therapeutic, in human blood, human serum, or an *in vitro* mixture containing one or more proteases.

[00164] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant exhibits at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, at least about 80%, at least about 90%, at least about 100% (or two-fold), at least about 2.5-fold, at least about 3-fold, at least about 3.5-fold, at least about 4-fold, at least about 4.5-fold, at least about 5-fold (at least about 5 times), at least about 6-fold, at least about 7-fold, at least about 8-fold, at least about 9-fold, at least about 10-fold, at least about 20-fold, at least about 30-fold, at least about 40-fold, at least about 50-fold, at least about 60-fold, at least about 70-fold, at least about 80-fold, at least about 90-fold, at least about 100-fold, at least about 200-fold, at least about 300-fold, at least about 400-fold, at least about 500-fold, at least about 600-fold, at least about 700-fold, at least about 800-fold, at least about 900-fold, or at least about 1000-fold, or more, greater resistance to one or more of  $\alpha$ -chymotrypsin, endoproteinase Arg-C, endoproteinase Asp-N, endoproteinase Glu-C, endoproteinase Lys-C, and trypsin, compared to the corresponding parent protein therapeutic.

[00165] In some embodiments, the extent of the increase in protease resistance of the polypeptide variant is determined by comparing the half-life of the polypeptide variant to the half-life of the corresponding parent protein therapeutic in human blood or human serum *in vitro*, or in an *in vitro* composition comprising one or more serum proteases. For example, the resistance to protease cleavage can be determined by detecting the level of a biological activity of a protease-resistant polypeptide variant following separately contacting the polypeptide variant and the corresponding parent protein therapeutic with a mixture of proteases, with human serum, or with human blood; and comparing the activity of the polypeptide variant to that of the corresponding parent protein therapeutic. If the biological activity of the polypeptide variant is higher than that of the corresponding parent protein therapeutic following incubation with human blood, human serum, or one or more proteases, then the polypeptide variant has increased protease resistance compared to the parent protein therapeutic.

[00166] The following is one non-limiting example of an *in vitro* assay for determining protease resistance. In separate containers, a polypeptide variant and the corresponding parent protein

therapeutic are added to a mixture of proteases containing 1.5 pg each of  $\alpha$ -chymotrypsin, carboxypeptidase, endoproteinase Arg-C, endoproteinase Asp-N, endoproteinase Glu-C, endoproteinase Lys-C, and trypsin, forming a reaction mixture; and the reaction mixture kept at 25°C for 30 minutes. At the end of the 30-minute reaction period, an agent that inhibits the activity of the proteases is added; and a biological activity of the polypeptide variant and the corresponding parent protein therapeutic is detected. The following is another non-limiting example of an *in vitro* assay for determining protease resistance. In separate containers, a polypeptide variant and the corresponding parent protein therapeutic are added to either a lysate of human blood, or human serum, forming a reaction mixture; and the reaction mixture is kept at 37°C for a suitable period of time (e.g., 5 minutes, 10 minutes, 15 minutes, 30 minutes, or 60 minutes, etc.). An agent that inhibits the activity of the proteases is then added; and a biological activity of the polypeptide variant and the corresponding parent protein therapeutic is detected.

[00167] The corresponding parent protein therapeutic can be any parent protein therapeutic that is proven to be effective in the treatment of the disease or condition in a patient when administered to the patient in an immediate release formulation by subcutaneous bolus injection of the second unit form at a suitable dosing frequency. In these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is effective in the treatment of the same disease or condition in the patient when administered to the patient orally in the first unit form at a dosing frequency that is no less often than that of the parent protein therapeutic regimen.

[00168] In many embodiments, a known hyperglycosylated, protease-resistant polypeptide variant exhibits a desired pharmacologic activity in a mammalian host, e.g., a hyperglycosylated, protease-resistant polypeptide variant can exhibit at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, or at least about 95%, of a desired pharmacologic activity of a corresponding parent protein therapeutic. As non-limiting examples, a hyperglycosylated, protease-resistant polypeptide variant can exhibit one or more of the following activities: antiproliferative activity, anti-viral activity, anti-fibrotic activity; hematopoietic activity; angiogenic activity; enzymatic activity; growth factor activity; chemokine activity; receptor agonist activity; receptor antagonist activity; and anti-angiogenic activity; where the activity is one that is desired of a corresponding parent protein therapeutic.

[00169] A known hyperglycosylated, protease-resistant polypeptide variant exhibits increased serum half-life or increased AUC compared to a parent protein therapeutic administered under similar conditions.

[00170] In some embodiments, a known hyperglycosylated, protease-resistant polypeptide variant has an increased serum half-life compared to the corresponding parent polypeptide. The term "serum half-life" is used interchangeably herein with the terms "plasma half-life," and "circulating half-life." In some embodiments, a hyperglycosylated, protease-resistant polypeptide variant has a serum half life that is at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, at least about 80%, at least about 90%, at least about 100% (or two-fold), at least about 2.5-fold, at least about 3-fold, at least about 3.5-fold, at least about 4-fold, at least about 4.5-fold, at least about 5-fold (at least about 5 times), at least about 6-fold, at least about 7-fold, at least about 8-fold, at least about 9-fold, at least about 10-fold, at least about 20-fold, at least about 30-fold, at least about 40-fold, at least about 50-fold, at least about 60-fold, at least about 70-fold, at least about 80-fold, at least about 90-fold, at least about 100-fold, at least about 200-fold, at least about 300-fold, at least about 400-fold, at least about 500-fold, at least about 600-fold, at least about 700-fold, at least about 800-fold, at least about 900-fold, or at least about 1000-fold, or more, greater than the serum half life of the corresponding parent protein therapeutic. In some embodiments, the extent of the increase in half-life of the known hyperglycosylated, protease-resistant polypeptide variant is determined by comparing the half-life of the known hyperglycosylated, protease-resistant polypeptide variant to the half-life of the corresponding parent protein therapeutic in human blood or human serum *in vivo*.

[00171] In some embodiments, the extent of the increase in half-life of the known hyperglycosylated, protease-resistant polypeptide variant is determined by comparing the half-life of the known hyperglycosylated, protease-resistant polypeptide variant to the half-life of the corresponding parent protein therapeutic in human blood or human serum *in vitro*, or in an *in vitro* composition comprising one or more serum proteases. For example, the resistance to protease cleavage can be determined by detecting the level of a biological activity of a known hyperglycosylated, protease-resistant polypeptide variant following separately contacting the polypeptide variant and the corresponding parent protein therapeutic with a mixture of proteases, with human serum, or with human blood; and comparing the activity of the polypeptide variant to that of the corresponding parent protein therapeutic. If the biological



activity of the polypeptide variant is higher than that of the corresponding parent protein therapeutic following incubation with human blood, human serum, or one or more proteases, then the polypeptide variant has an increased half-life compared to the parent protein therapeutic.

[00172] In some embodiments, a known hyperglycosylated, protease-resistant polypeptide variant has an AUC that is at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, at least about 80%, at least about 90%, at least about 100% (or two-fold), at least about 2.5-fold, at least about 3-fold, at least about 3.5-fold, at least about 4-fold, at least about 4.5-fold, or at least about 5-fold greater than the AUC of the corresponding parent protein therapeutic when administered under similar conditions.

[00173] The serum half-life or AUC of a known hyperglycosylated, protease-resistant polypeptide variant can be readily determined using well known methods. For example, a known hyperglycosylated, protease-resistant polypeptide variant is detectably labeled, and is administered to an individual (e.g., an experimental non-human animal, or a human subject), and, at various time points following administration of the hyperglycosylated, protease-resistant polypeptide variant, a blood sample is drawn and the amount of detectably labeled hyperglycosylated, protease-resistant polypeptide variant in the blood sample is determined.

### **3D-scanning methods**

[00174] A glycosylated or protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic can be generated using a 3D-scanning (structural homology) method. Structural homology refers to homology between the topology and three-dimensional structure of two proteins. Numerous methods are well known in the art for identifying structurally related amino acid positions with 3-dimensionally structurally homologous proteins. Exemplary methods include, but are not limited to: CATH (Class, Architecture, Topology and Homologous superfamily) which is a hierarchical classification of protein domain structures based on four different levels (Orengo et al., *Structure*, 5(8): 1093-1108, 1997); CE (Combinatorial Extension of the optimal path), which is a method that calculates pairwise structure alignments (Shindyalov et al., *Protein Engineering*, 11 (9):739-747, 1998); FSSP (Fold classification based on Structure-Structure alignment of Proteins), which is a database based on the complete comparison of all 3-dimensional protein structures that currently reside in the Protein Data Bank (PDB) (Holm et al., *Science*, 273:595-602, 1996); SCOP (Structural Classification of Proteins), which provides a descriptive database

based on the structural and evolutionary relationships between all proteins whose structure is known (Murzin et al., J. Mol. Biol., 247:536-540, 1995); and VAST (Vector Alignment Search Tool), which compares newly determined 3-dimensional protein structure coordinates to those found in the MMDB/PDB database (Gibrat et al., Current Opinion in Structural Biology, 6:377-385, 1995).

[00175] As one non-limiting example, IFN- $\alpha$ 2b mutants with increased resistance to proteolysis are generated by a 2-dimensional rational scanning method; and the corresponding residues on members of cytokine families that possess structural homology to IFN- $\alpha$ 2b are identified and the identified residues on the other cytokines are similarly modified to produce cytokines with increased resistance to proteolysis. See, e.g., WO 04/022593.

#### Protein therapeutics

[00176] A known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a variant of a polypeptide that has a therapeutic function in a mammalian host ("a parent protein therapeutic") in the treatment of a disease or condition in the mammalian host. A known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant treats the same disease or condition in the host as a parent protein therapeutic.

[00177] It should be noted that, in the context of amino acid replacements for generating protease-resistant variants of a parent protein therapeutic, the numbering of amino acids used to describe amino acid replacements that alter a protease cleavage site coincides with the numbering of amino acids as set forth in **Figures 1-23**. In the context of amino acid replacements for generating hyperglycosylation variants of the parent protein therapeutic, the numbering of amino acids used to describe amino acid replacements that generate a glycosylation site coincides with the numbering of amino acids as set forth in **Figures 24-30**. The corresponding amino acid positions of an IFN- $\alpha$  depicted in, e.g., Figure 1 and Figure 24 is readily identified. For example, it will be readily apparent to those skilled in the art that D99 of IFN- $\alpha$ 2b depicted in Figure 24 corresponds to D71 of IFN- $\alpha$ 2b depicted in Figure 2, and corresponds to D71 of IFN- $\alpha$ 2a depicted in Figure 1. Thus, e.g., D99 and D105 of the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 24 correspond to D71 and D77, respectively of the IFN- $\alpha$ 2a amino acid sequence depicted in Figure 1 and of the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 2; R50 of the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 24 corresponds to R23 of the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 2; D99, D105, and E134 of the Infergen amino acid sequence depicted in Figure 24 correspond to D71, D77, and D106, respectively, of the consensus IFN- $\alpha$  amino acid sequence set forth in Figure 9; the S99, E134, and F136 amino acid positions of the IFN- $\beta$ 1 amino acid sequence set forth in Figure 24

correspond to S74, E109, and F111, respectively, in the IFN- $\beta$  amino acid sequence set forth in Figure 3; and the E38, S40, and S99 amino acid positions of the IFN- $\gamma$  amino acid sequence set forth in Figure 31 correspond to E41, S43, and S102, respectively, of the IFN- $\gamma$  amino acid sequence set forth in Figure 4.

[00178] Suitable protease-resistant or protease-resistant, hyperglycosylated polypeptide variants include protease-resistant or protease-resistant, hyperglycosylated forms of any parent protein therapeutic that a mammalian host is in need of, including, but not limited to: an **interferon** (e.g., IFN- $\gamma$ , IFN- $\alpha$ , IFN- $\beta$ , IFN- $\omega$ ; IFN- $\tau$ ; as described in more detail below); an **insulin** (e.g., Novolin, Humulin, Humalog, Lantus, Ultralente, etc.); an **erythropoietin** (e.g., Procrit®, Eprex®, or Epogen® (epoetin- $\alpha$ ); Aranesp® (darbepoietin- $\alpha$ ); NeoRecormon®, Epogin® (epoetin- $\beta$ ); and the like); an **antibody** (e.g., a **monoclonal antibody**) (e.g., Rituxan® (rituximab); Remicade® (infliximab); Herceptin® (trastuzumab); Humira™ (adalimumab); Xolair® (omalizumab); Bexxar® (tositumomab); Raptiva™ (efalizumab); Erbitux™ (cetuximab); and the like), including an antigen-binding fragment of a monoclonal antibody; a **blood factor** (e.g., Activase® (alteplase) tissue plasminogen activator; NovoSeven® (recombinant human factor VIIa); Factor VIIa; Factor VIII (e.g., Kogenate®); Factor IX;  $\beta$ -globin; hemoglobin; and the like); a **colony stimulating factor** (e.g., Neupogen® (filgrastim; G-CSF); Neulasta (pegfilgrastim); granulocyte colony stimulating factor (G-CSF), granulocyte-monocyte colony stimulating factor, macrophage colony stimulating factor, megakaryocyte colony stimulating factor; and the like); a **growth hormone** (e.g., a somatotropin, e.g., Genotropin®, Nutropin®, Norditropin®, Saizen®, Serostim®, Humatrope®, etc.; a human growth hormone; and the like); an **interleukin** (e.g., IL-1; IL-2, including, e.g., Proleukin®; IL-3, IL-4, IL-5, IL-6, IL-7, IL-8, IL-9; etc.); a **growth factor** (e.g., Regranex® (beclapernin; PDGF); Fiblast® (trafermin; bFGF); Stemgen® (ancestim; stem cell factor); keratinocyte growth factor; an acidic fibroblast growth factor, a stem cell factor, a basic fibroblast growth factor, a hepatocyte growth factor; and the like); a **soluble receptor** (e.g., a TNF- $\alpha$ -binding soluble receptor such as Enbrel® (etanercept); a soluble VEGF receptor; a soluble interleukin receptor; a soluble  $\gamma/\delta$  T cell receptor; and the like); an **enzyme** (e.g.,  $\alpha$ -glucosidase; Cerazyme® (imiglucrase;  $\beta$ -glucocerebrosidase, Ceredase® (alglucerase; ); an **enzyme activator** (e.g., tissue plasminogen activator); a **chemokine** (e.g., IP-10; Mig; Gro $\alpha$ /IL-8, RANTES; MIP-1 $\alpha$ ; MIP-1 $\beta$ ; MCP-1; PF-4; and the like); an **angiogenic agent** (e.g., vascular endothelial growth factor (VEGF) ; an **anti-angiogenic agent** (e.g., a soluble VEGF receptor); a protein vaccine; a **neuroactive peptide** such as bradykinin, cholecystokinin, gastein, secretin, oxytocin, gonadotropin-releasing hormone, beta-endorphin,

enkephalin, substance P, somatostatin, prolactin, galanin, growth hormone-releasing hormone, bombesin, warfarin, dynorphin, neurotensin, motilin, thyrotropin, neuropeptide Y, luteinizing hormone, calcitonin, insulin, glucagon, vasopressin, angiotensin II, thyrotropin-releasing hormone, vasoactive intestinal peptide, a sleep peptide, etc.; **other proteins** such as a thrombolytic agent, an atrial natriuretic peptide, bone morphogenic protein, thrombopoietin, relaxin, glial fibrillary acidic protein, follicle stimulating hormone, a human alpha-1 antitrypsin, a leukemia inhibitory factor, a transforming growth factor, a tissue factor, an insulin-like growth factor, a luteinizing hormone, a follicle stimulating hormone, a macrophage activating factor, tumor necrosis factor, a neutrophil chemotactic factor, a nerve growth factor, a tissue inhibitor of metalloproteinases; a vasoactive intestinal peptide, angiogenin, angiotropin, fibrin; hirudin; a leukemia inhibitory factor; an IL-1 receptor antagonist (e.g., Kineret® (anakinra)); and the like. Also suitable for use are fusion proteins comprising all or a portion of any of the foregoing proteins.

**[00179]** As mentioned above, a known protease-resistant or protease-resistant, hyperglycosylated protein variant exhibits at least one desired pharmacologic activity of the corresponding parent protein. Examples of useful assays for particular therapeutic proteins include, but are not limited to, GM-CSF (Eaves, A. C. and Eaves C. J., Erythropoiesis in culture. In: McCulloch E A (ed) Cell culture techniques--Clinics in hematology. W B Saunders, Eastbourne, pp 371-91 (1984); Metcalf, D., International Journal of Cell Cloning 10: 116-25 (1992); Testa, N. G., et al., Assays for hematopoietic growth factors. In: Balkwill F R (ed) Cytokines A practical Approach, pp 229-44; IRL Press Oxford 1991) EPO (bioassay: Kitamura et al., J. Cell. Physiol. 140 p323 (1989)); Hirudin (platelet aggregation assay: Blood Coagul Fibrinolysis 7(2):259-61 (1996)); IFN $\alpha$  (anti-viral assay: Rubinstein et al., J. Virol. 37(2):755-8 (1981); anti-proliferative assay: Gao Y, et al Mol Cell Biol. 19(11):7305-13 (1999); and bioassay: Czarniecki et al., J. Virol. 49 p490 (1984)); G-CSF (bioassay: Shirafuji et al., Exp. Hematol. 17 p116 (1989); proliferation of murine NFS-60 cells (Weinstein et al, Proc Natl Acad Sci 83:5010-4 (1986)); insulin ( $^3$ H-glucose uptake assay: Steppan et al., Nature 409(6818):307-12 (2001)); hGH (Ba/F3-hGHR proliferation assay: J Clin Endocrinol Metab 85(11):4274-9 (2000); International standard for growth hormone: Horm Res, 51 Suppl 1:7-12 (1999)); factor X (factor X activity assay: Van Wijk et al. Thromb Res 22:681-686 (1981)); factor VII (coagulation assay using prothrombin clotting time: Belaaouaj et al., J. Biol. Chem. 275:27123-8(2000); Diaz-Collier et al., Thromb Haemost 71:339-46 (1994)).

## Interferons

- [00180] In some embodiments, the parent protein therapeutic is an interferon, and a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises (1) a carbohydrate moiety covalently attached to at least one non-native glycosylation site not found in the parent interferon or (2) a carbohydrate moiety covalently attached to at least one native glycosylation site found but not glycosylated in the parent interferon; and comprises one or more mutated protease cleavage sites in place of a native protease cleavage site found in the parent protein therapeutic.
- [00181] In some embodiments, the parent polypeptide is a Type I interferon receptor polypeptide agonist. Type I interferon receptor polypeptide agonists include IFN- $\alpha$ , IFN- $\beta$ , IFN- $\tau$ , and IFN- $\omega$ . Thus, e.g., a protease-resistant or protease-resistant, hyperglycosylated polypeptide variant can be a protease-resistant or protease-resistant, hyperglycosylated Type I interferon receptor polypeptide agonist variant, including hyperglycosylated IFN- $\alpha$ , IFN- $\beta$ , IFN- $\tau$ , and IFN- $\omega$  variants that lack at least one protease cleavage site found in the parent protein.
- [00182] In other embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is any protease-resistant or protease-resistant, glycosylated synthetic Type I interferon receptor polypeptide agonist described in the U.S. Provisional Patent Application for "Synthetic Type I Interferon Receptor Polypeptide Agonists" (USSN 60/600,202) filed on August 9, 2004<sup>§</sup> the entire disclosure of which application is incorporated herein by reference.
- [00183] In other embodiments, the parent polypeptide is a Type II interferon receptor polypeptide agonist. Type II interferon receptor polypeptide agonists include interferon-gamma (IFN- $\gamma$ ). Thus, e.g., a protease-resistant or protease-resistant, hyperglycosylated polypeptide variant can be a protease-resistant or protease-resistant, hyperglycosylated Type II interferon receptor polypeptide agonist variant, including hyperglycosylated IFN- $\gamma$  that lacks at least one protease cleavage site found in the parent protein.
- IFN- $\alpha$*
- [00184] The amino acid sequence of any known IFN- $\alpha$  can be modified to generate a subject synthetic Type I interferon receptor polypeptide agonist. The term "interferon-alpha" as used herein refers to a family of related polypeptides that inhibit viral replication and cellular proliferation and modulate immune response.
- [00185] Suitable alpha interferons include, but are not limited to, naturally-occurring IFN- $\alpha$  (including, but not limited to, naturally occurring IFN- $\alpha$ 2a, IFN- $\alpha$ 2b, and IFN- $\alpha$ 14); an IFN- $\alpha$

as described in U.S. Patent No. 6,704,225; recombinant interferon alpha-2b such as Intron-A interferon available from Schering Corporation, Kenilworth, N.J.; recombinant interferon alpha-2a such as Roferon interferon available from Hoffmann-La Roche, Nutley, N. J.; recombinant interferon alpha-2C such as Berofer alpha 2 interferon available from Boehringer Ingelheim Pharmaceutical, Inc., Ridgefield, Conn.; interferon alpha-n1, a purified blend of natural alpha interferons such as Sumiferon available from Sumitomo, Japan or as Wellferon interferon alpha-n1 (INS) available from the Glaxo-Wellcome Ltd., London, Great Britain; and interferon alpha-n3 a mixture of natural alpha interferons made by Interferon Sciences and available from the Purdue Frederick Co., Norwalk, Conn., under the Alferon Tradename; and IFN- $\alpha$ 14.

[00186] Suitable known protease-resistant or protease-resistant, hyperglycosylated polypeptide variants include protease-resistant or protease-resistant, hyperglycosylated forms of any parent alpha interferon polypeptide. In one aspect, a known protease-resistant or protease-resistant, hyperglycosylated variant of a parent alpha interferon polypeptide has an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide; and further comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent protein.

[00187] In another aspect, the parent polypeptide is IFN- $\alpha$ 2a and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N]IFN- $\alpha$ 2a glycopeptide, where the [D99N]IFN- $\alpha$ 2a glycopeptide is a variant of IFN- $\alpha$ 2a having (a) an asparagine residue in place of the native aspartic acid residue at amino acid position 99 in the amino acid sequence of IFN- $\alpha$ 2a and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue. It will be appreciated that the amino acid sequence of IFN- $\alpha$ 2a is the same as the amino acid sequence of IFN- $\alpha$ 2b depicted in Figure 1, provided that the IFN- $\alpha$ 2a sequence has a lysine residue in place of the arginine residue at amino acid position 50 in the IFN- $\alpha$ 2b sequence shown in Figure 1.

[00188] In another aspect, the parent polypeptide is IFN- $\alpha$ 2a and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N, D105N]IFN- $\alpha$ 2a glycopeptide, where the [D99N, D105N]IFN- $\alpha$ 2a glycopeptide is a variant of IFN- $\alpha$ 2a having (a) an asparagine residue in place of the native aspartic acid residue at each of amino acid positions 99 and 105 in the amino acid sequence of IFN- $\alpha$ 2a and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues. It will be appreciated that the amino acid sequence of IFN- $\alpha$ 2a is the same as the amino acid sequence of IFN- $\alpha$ 2b

depicted in Figure 1, provided that the IFN- $\alpha$ 2a sequence has a lysine residue in place of the arginine residue at amino acid position 50 in the IFN- $\alpha$ 2b sequence shown in Figure 1.

[00189] In another aspect, the parent polypeptide is IFN- $\alpha$ 2b and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N]IFN- $\alpha$ 2b glycopeptide, where the [D99N]IFN- $\alpha$ 2b glycopeptide is a variant of IFN- $\alpha$ 2b having (a) an asparagine residue in place of the native aspartic acid residue at amino acid position 99 in the amino acid sequence of IFN- $\alpha$ 2b depicted in Figure 1 and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.

[00190] In another aspect, the parent polypeptide is IFN- $\alpha$ 2b and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N, D105N]IFN- $\alpha$ 2b glycopeptide, where the [D99N, D105N]IFN- $\alpha$ 2b glycopeptide is a variant of IFN- $\alpha$ 2b having (a) an asparagine residue in place of the native aspartic acid residue at each of amino acid positions 99 and 105 in the amino acid sequence of IFN- $\alpha$ 2b depicted in Figure 1 and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

[00191] Suitable alpha interferons further include consensus IFN- $\alpha$ . Consensus IFN- $\alpha$  (also referred to as "CIFN" and "IFN-con" and "consensus interferon") encompasses but is not limited to the amino acid sequences designated IFN-con<sub>1</sub>, IFN-con<sub>2</sub> and IFN-con<sub>3</sub> which are disclosed in U.S. Pat. Nos. 4,695,623 and 4,897,471; and consensus interferon as defined by determination of a consensus sequence of naturally occurring interferon alphas (e.g., Infergen®, InterMune, Inc., Brisbane, Calif.). IFN-con<sub>1</sub> is the consensus interferon agent in the Infergen® alfacon-1 product. The Infergen® consensus interferon product is referred to herein by its brand name (Infergen®) or by its generic name (interferon alfacon-1).

[00192] Suitable known protease-resistant or protease-resistant, hyperglycosylated polypeptide variants include hyperglycosylated forms of any parent consensus IFN- $\alpha$  polypeptide; where the variant lacks at least one protease cleavage site found in the parent protein. In one aspect, a known protease-resistant or protease-resistant, hyperglycosylated variant of a parent consensus IFN- $\alpha$  polypeptide has an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in a parent polypeptide; and where the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent protein.

[00193] In another aspect, the parent polypeptide is the interferon alfacon-1 polypeptide and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N]interferon alfacon-1 glycopeptide, where the [D99N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted

for the native aspartic acid residue at amino acid position 99 in the amino acid sequence of Infergen (interferon alfacon-1) depicted in Figure 1 and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.

[00194] In another aspect, the parent polypeptide is the interferon alfacon-1 polypeptide and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N, D105N]interferon alfacon-1 glycopeptide, where the [D99N, D105N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid residues at amino acid positions 99 and 105 in the amino acid sequence of Infergen depicted in Figure 1 and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

[00195] In another aspect, the parent polypeptide is the interferon alfacon-1 polypeptide and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N, D105N, E134N]interferon alfacon-1 glycopeptide, where the [D99N, D105N, E134N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid, aspartic acid, and glutamic acid residues at amino acid positions 99, 105 and 134, respectively, in the amino acid sequence of Infergen depicted in Figure 1 and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

[00196] In another aspect, the parent polypeptide is the interferon alfacon-1 polypeptide and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N, E134N]interferon alfacon-1 glycopeptide, where the [D99N, E134N] interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid and glutamic acid residues at amino acid positions 99 and 134, respectively, in the amino acid sequence of Infergen depicted in Figure 1 and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

[00197] In another aspect, the parent polypeptide is the interferon alfacon-1 polypeptide and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D105N, E134N]interferon alfacon-1 glycopeptide, where the [D105N, E134N] interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid and glutamic acid residues at amino acid positions 105 and 134, respectively, in the amino acid sequence of Infergen depicted in Figure 1 and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.



[00198] In another aspect, the parent polypeptide is the interferon alfacon-1 polypeptide and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N, D105N, E134T]interferon alfacon-1 glycopeptide, where the [D99N, D105N, E134T]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid residues at amino acid positions 99 and 105 in the amino acid sequence of Infergen depicted in Figure 1 (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of Infergen depicted in Figure 1 and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues.

[00199] In another aspect, the parent polypeptide is the interferon alfacon-1 polypeptide and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D99N, E134T]interferon alfacon-1 glycopeptide, where the [D99N, E134T]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 99 in the amino acid sequence of Infergen depicted in Figure 1 (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of Infergen depicted in Figure 1 and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues.

[00200] In another aspect, the parent polypeptide is the interferon alfacon-1 polypeptide and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [D105N, E134T]interferon alfacon-1 glycopeptide, where the [D105N, E134T]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 105 in the amino acid sequence of Infergen depicted in Figure 1 (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of Infergen depicted in Figure 1 and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues.

[00201] The numbering of amino acids, discussed in the context of amino acid replacements for generating hyperglycosylation variants of the parent protein therapeutic, coincides with the numbering of amino acids used to depict the Type I interferon amino acid sequences appearing in Figure 24. In the context of amino acid replacements, for generating protease-resistant variants of the parent protein therapeutic, the numbering of amino acids used to describe IFN- $\alpha$  variants coincides with the numbering of amino acids as depicted in Figure 1.

[00202] In another aspect, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent interferon-alpha therapeutic differs from the parent interferon-alpha therapeutic to the extent that the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises (1) a carbohydrate moiety covalently attached to a non-native glycosylation site not found in the parent interferon-alpha therapeutic and/or (2) a carbohydrate moiety covalently attached to a native glycosylation site found but not glycosylated in the parent interferon-alpha therapeutic; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\alpha$  protein therapeutic.

*IFN- $\beta$*

[00203] The amino acid sequence of any known IFN- $\beta$  can be modified to generate a subject synthetic Type I interferon receptor polypeptide agonist. The term interferon-beta ("IFN- $\beta$ ") includes IFN- $\beta$  polypeptides that are naturally occurring; and non-naturally-occurring IFN- $\beta$  polypeptides. Suitable beta interferons include, but are not limited to, naturally-occurring IFN- $\beta$ ; IFN- $\beta$ 1a, e.g., Avonex® (Biogen, Inc.), and Rebif® (Serono, SA); IFN- $\beta$ 1b (Betaseron®; Berlex); and the like. Amino acid sequences of IFN- $\beta$  are publicly available; for example, human IFN- $\beta$ 1 amino acid sequence is found under GenBank Accession No. NP\_002167 and is depicted in Figure 24 (SEQ ID NO:\*\*). A human IFN- $\beta$  amino acid sequence is also depicted in Figure 3.

[00204] Suitable known protease-resistant or protease-resistant, hyperglycosylated polypeptide variants include hyperglycosylated forms of any parent IFN- $\beta$  polypeptide. In one aspect, a known protease-resistant or protease-resistant, hyperglycosylated variant of a parent IFN- $\beta$  polypeptide has an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\beta$  polypeptide.

[00205] The numbering of amino acids, discussed in the context of amino acid replacements for generating hyperglycosylation variants of the parent protein therapeutic, coincides with the numbering of amino acids used to depict the Type I interferon amino acid sequences appearing in Figure 24. In the context of amino acid replacements, for generating protease-resistant variants of the parent protein therapeutic, the numbering of amino acids used to describe IFN- $\beta$  variants coincides with the numbering of amino acids as depicted in Figure 3.

[00206] In another aspect, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent interferon-beta therapeutic differs from the parent interferon-

beta therapeutic to the extent that the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises (1) a carbohydrate moiety covalently attached to a non-native glycosylation site not found in the parent interferon-beta therapeutic and/or (2) a carbohydrate moiety covalently attached to a native glycosylation site found but not glycosylated in the parent interferon-beta therapeutic; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\beta$  polypeptide.

*IFN-tau*

[00207] The amino acid sequence of any known IFN-tau can be modified to generate a subject synthetic Type I interferon receptor polypeptide agonist. The term interferon-tau includes IFN-tau polypeptides that are naturally occurring; and non-naturally-occurring IFN-tau polypeptides. Suitable tau interferons include, but are not limited to, naturally-occurring IFN-tau; Tauferon® (Pepgen Corp.); and the like. IFN-tau may comprise an amino acid sequence as set forth in any one of GenBank Accession Nos. P15696; P56828; P56832; P56829; P56831; Q29429; Q28595; Q28594; S08072; Q08071; Q08070; Q08053; P56830; P28169; P28172; and P28171. Any protease-resistant or protease-resistant, hyperglycosylated IFN-tau polypeptide variant that retains a desired pharmacologic activity of IFN-tau may be used in the methods or compositions of the invention.

[00208] Suitable known protease-resistant or protease-resistant, hyperglycosylated polypeptide variants include protease-resistant or protease-resistant, hyperglycosylated forms of any parent IFN-tau polypeptide. In one aspect, a known protease-resistant or protease-resistant, hyperglycosylated variant of a parent IFN-tau polypeptide has an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in a parent IFN-tau polypeptide.

*IFN- $\omega$*

[00209] The amino acid sequence of any known IFN-omega can be modified to generate a subject synthetic Type I interferon receptor polypeptide agonist. The term interferon-omega ("IFN- $\omega$ ") includes IFN- $\omega$  polypeptides that are naturally occurring; and non-naturally-occurring IFN- $\omega$  polypeptides. Suitable IFN- $\omega$  include, but are not limited to, naturally-occurring IFN- $\omega$ ; recombinant IFN- $\omega$ , e.g., Biomed 510 (BioMedicines); and the like. IFN- $\omega$  may comprise an amino acid sequence as set forth in GenBank Accession No. NP\_002168; or AAA70091.

- [00210] Suitable known protease-resistant or protease-resistant, hyperglycosylated polypeptide variants include protease-resistant or protease-resistant, hyperglycosylated forms of any parent IFN- $\omega$  polypeptide. In one aspect, a known protease-resistant or protease-resistant, hyperglycosylated variant of a parent IFN- $\omega$  polypeptide has an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.
- [00211] In another aspect, the parent polypeptide is IFN- $\omega$ 1 and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [R99N]IFN- $\omega$ 1 glycopeptide, where the [R99N]IFN- $\omega$ 1 glycopeptide is a variant of IFN- $\omega$ 1 having (a) an asparagine residue substituted for the native arginine residue at amino acid position 99 in the amino acid sequence of IFN- $\omega$ 1 and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue; where the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.
- [00212] In another aspect, the parent polypeptide is IFN- $\omega$ 1 and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [G134N]IFN- $\omega$ 1 glycopeptide, where the [G134N]IFN- $\omega$ 1 glycopeptide is a variant of IFN- $\omega$ 1 having (a) an asparagine residue substituted for the native glycine residue at amino acid position 134 in the amino acid sequence of IFN- $\omega$ 1 and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue; where the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.
- [00213] In another aspect, the parent polypeptide is IFN- $\omega$ 1 and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [G134T]IFN- $\omega$ 1 glycopeptide, where the [G134T]IFN- $\omega$ 1 glycopeptide is a variant of IFN- $\omega$ 1 having (a) an threonine residue substituted for the native glycine residue at amino acid position 134 in the amino acid sequence of IFN- $\omega$ 1 and (b) a carbohydrate moiety covalently attached to the R-group of said threonine residue; where the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.
- [00214] In another aspect, the parent polypeptide is IFN- $\omega$ 1 and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [S99N, G134N]IFN- $\omega$ 1 glycopeptide, where the [S99N, G134N]IFN- $\omega$ 1 glycopeptide is a variant of IFN- $\omega$ 1 having (a) asparagine residues substituted for the native serine and glycine residues at amino acid positions 99 and 134, respectively, in the amino acid sequence of IFN- $\omega$ 1 and (b) a

carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; where the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00215] In another aspect, the parent polypeptide is IFN- $\omega$ 1 and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is an [S99N, G134T]IFN- $\omega$ 1 glycopeptide, where the [S99N, G134T]IFN- $\omega$ 1 glycopeptide is a variant of IFN- $\omega$ 1 having (a) asparagine and threonine residues substituted for the native serine and glycine residues at amino acid positions 99 and 134, respectively, in the amino acid sequence of IFN- $\omega$ 1 (as set forth in Figure 24) and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residue; where the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00216] The numbering of amino acids, discussed in the context of amino acid replacements for generating hyperglycosylation variants of the parent protein therapeutic, coincides with the numbering of amino acids used to depict the Type I interferon amino acid sequences appearing in Figure 24. In the context of amino acid replacements, for generating protease-resistant variants of the parent protein therapeutic, the numbering of amino acids used to describe IFN- $\omega$  variants coincides with the numbering of amino acids as depicted in Figure 1.

[00217] In another aspect, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent interferon- $\omega$  therapeutic differs from the parent interferon- $\omega$  therapeutic to the extent that the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises (1) a carbohydrate moiety covalently attached to a non-native glycosylation site not found in the parent interferon- $\omega$  therapeutic and/or (2) a carbohydrate moiety covalently attached to a native glycosylation site found but not glycosylated in the parent interferon- $\omega$  therapeutic; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

#### *Interferon-Gamma*

[00218] The nucleic acid sequences encoding IFN- $\gamma$  polypeptides may be accessed from public databases, e.g., GenBank, journal publications, and the like. While various mammalian IFN- $\gamma$  polypeptides are of interest, for the treatment of human disease, generally the human protein will be used. Human IFN- $\gamma$  coding sequence may be found in Genbank, accession numbers X13274; V00543; and NM\_000619. The corresponding genomic sequence may be found in Genbank, accession numbers J00219; M37265; and V00536. See, for

example. Gray *et al.* (1982) *Nature* 295:501 (Genbank X13274); and Rinderknecht *et al.* (1984) *J.B.C.* 259:6790. In some embodiments, the IFN- $\gamma$  is glycosylated.

[00219] IFN- $\gamma$ 1b (Actimmune®; human interferon) is a single-chain polypeptide of 140 amino acids. It is made recombinantly in *E.coli* and is unglycosylated (Rinderknecht *et al.* 1984, *J. Biol. Chem.* 259:6790-6797). Recombinant IFN-gamma as discussed in U.S. Patent No. 6,497,871 is also suitable for use herein.

[00220] The term "IFN-gamma" includes any of natural IFN-gamma, recombinant IFN-gamma and the derivatives thereof so far as they have an IFN- $\gamma$  activity, particularly human IFN-gamma activity. Human IFN-gamma exhibits the antiviral and anti-proliferative properties characteristic of the interferons, as well as a number of other immunomodulatory activities, as is known in the art. Although IFN-gamma is based on the sequences as provided above, the production of the protein and proteolytic processing can result in processing variants thereof. The unprocessed sequence provided by Gray *et al.*, *supra*, consists of 166 amino acids (aa). Although the recombinant IFN-gamma produced in *E. coli* was originally believed to be 146 amino acids, (commencing at amino acid 20) it was subsequently found that native human IFN-gamma is cleaved after residue 23, to produce a 143 aa protein, or 144 aa if the terminal methionine is present, as required for expression in bacteria. During purification, the mature protein can additionally be cleaved at the C terminus after residue 162 (referring to the Gray *et al.* sequence), resulting in a protein of 139 amino acids, or 140 amino acids if the initial methionine is present, *e.g.* if required for bacterial expression. The N-terminal methionine is an artifact encoded by the mRNA translational "start" signal AUG that, in the particular case of *E. coli* expression is not processed away. In other microbial systems or eukaryotic expression systems, methionine may be removed.

[00221] Any of the native IFN-gamma peptides, modifications and variants thereof, or a combination of one or more peptides can serve as a parent polypeptide referent in connection with the present methods and/or compositions. IFN-gamma peptides of interest include fragments, and can be variously truncated at the carboxyl terminus relative to the full sequence. Such fragments continue to exhibit the characteristic properties of human gamma interferon, so long as amino acids 24 to about 149 (numbering from the residues of the unprocessed polypeptide) are present. Extraneous sequences can be substituted for the amino acid sequence following amino acid 155 without loss of activity. See, for example, U.S. Patent No. 5,690,925. Native IFN-gamma moieties include molecules variously extending from amino acid residues 24-150; 24-151, 24-152; 24- 153, 24-155; and 24-157.

[00222] " Any known protease-resistant or protease-resistant, hyperglycosylated IFN-gamma polypeptide variant that retains a desired pharmacologic activity of a parent IFN-gamma polypeptide may be used in the methods and/or compositions of the invention.

[00223] In another aspect, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent interferon-gamma therapeutic differs from the parent interferon-gamma therapeutic to the extent that the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises (1) a carbohydrate moiety covalently attached to a non-native glycosylation site not found in the parent interferon-gamma therapeutic and/or (2) a carbohydrate moiety covalently attached to a native glycosylation site found but not glycosylated in the parent interferon-gamma therapeutic; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide.

[00224] In another aspect, the parent protein therapeutic is interferon gamma-1b and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent interferon gamma-1b therapeutic is a protease-resistant variant of glycosylated native (wild-type) human IFN- $\gamma$ . Glycosylated native (wild-type) human IFN- $\gamma$  is described in WO 02/081507.

#### Erythropoietin

[00225] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises an erythropoietin amino acid sequence comprising at least one non-native glycosylation site compared to a parent erythropoietin polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent EPO polypeptide. Suitable erythropoietin polypeptides include those proteins that have the biological activity of human erythropoietin such as erythropoietin analogs; erythropoietin isoforms; erythropoietin fragments; hybrid erythropoietin proteins; fusion proteins; and oligomers and multimers of any of the foregoing.

[00226] Specific examples of erythropoietin include, but are not limited to, human erythropoietin (see, e.g., Jacobs et al. (1985) *Nature* 313:806-810; and Lin et al. (1985) *Proc Natl Acad Sci USA* 82:7580-7584); erythropoietin polypeptides discussed in U.S. Patent Nos. 6,696,056 and 6,585,398; the amino acid sequences provided in GenBank Accession Nos. NP\_00790 and CAA26095; Epoetin alfa (EPREX®; ERYPO®); Novel erythropoiesis stimulating protein (NESP) (a hyperglycosylated analog of recombinant human erythropoietin (Epoetin) described in European patent application EP640619); human erythropoietin analog--human serum albumin fusion proteins described in International patent application

WO9966054; erythropoietin mutants described in International patent application WO9938890; erythropoietin omega, which may be produced from an Apa I restriction fragment of the human erythropoietin gene described in U.S. Pat. No. 5,688,679; altered glycosylated human erythropoietin described in International patent application WO9911781; PEG conjugated erythropoietin analogs described in WO9805363 or U.S. Pat. No. 5,643,575. Specific examples of cell lines modified for expression of endogenous human erythropoietin are described in international patent applications WO9905268 and WO9412650.

[00227] In one aspect, a known protease-resistant or protease-resistant, hyperglycosylated variant of a parent erythropoietin polypeptide retains the hematopoietic activity of the parent erythropoietin as determined by monitoring and measurement of the patient's hematocrit.

[00228] In another aspect, the parent polypeptide is EPOGEN® epoetin alfa and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a protease-resistant variant of ARANESP® darbepoetin alfa.

### **Insulin**

[00229] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises an insulin amino acid sequence comprising at least one non-native glycosylation site compared to a parent insulin polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent insulin polypeptide. Suitable insulin polypeptides include, but are not limited to, proinsulin, preproinsulin, and the insulin forms disclosed in U.S. Patent Nos. 4,992,417; 4,992,418; 5,474,978; 5,514,646; 5,504,188; 5,547,929; 5,650,486; 5,693,609; 5,700,662; 5,747,642; 5,922,675; 5,952,297; 6,034,054; and 6,211,144; and published PCT applications WO 00/121197; WO 09/010645; and WO 90/12814. Insulin analogs include, but are not limited to, superactive insulin analogs, monomeric insulins, and hepatospecific insulin analogs. Various forms of insulin include Humalog®; Humalog® Mix 50/50™; Humalog® Mix 75/25™; Humulin® 50/50; Humulin® 70/30; Humulin® L; Humulin® N; Humulin® R; Humulin® Ultralente; Lantus®; Lente® Iletin® II; Lente® Insulin; Lente® L; Novolin® 70/30; Novolin® L; Novolin® N; Novolin® R; NovoLog™; NPH Iletin® I; NPH-N; Pork NPH Iletin® II; Pork Regular Iletin® II; Regular (Concentrated) Iletin® II U-500; Regular Iletin® I; and Velosulin® BR Human (Buffered).

[00230] Insulin polypeptides suitable for modification and use according to the present invention include analogs of human insulin wherein position B28 is Asp, Lys, Leu, Val or Ala and position B29 is Lys or Pro; des(B28-B30) human insulin; des(B27) human insulin; des(B30) human insulin; an analog of human insulin in which position B28 is Asp and position



B29 is Lys or Pro; an analog of human insulin in which position B28 is Lys, and position B29 is Lys or Pro; Asp<sup>B28</sup> human insulin; Lys<sup>B28</sup> Pro<sup>B29</sup> human insulin; B29-N<sup>ε</sup>-myristoyl-des(B30) human insulin; B29-N<sup>ε</sup>-palmitoyl-des(B30) human insulin; B29-N<sup>ε</sup>-myristoyl human insulin; B29-N<sup>ε</sup>-palmitoyl human insulin; B28-N<sup>ε</sup>-myristoyl Lys<sup>B28</sup> Pro<sup>B29</sup> human insulin; B28-N<sup>ε</sup>-palmitoyl Lys<sup>B28</sup> Pro<sup>B29</sup> human insulin; B30-N<sup>ε</sup>-myristoyl-Thr<sup>B29</sup> Lys<sup>B30</sup> human insulin; B30-N<sup>ε</sup>-palmitoyl-Thr<sup>B29</sup> Lys<sup>B30</sup> human insulin; B29-N<sup>ε</sup>-(N-palmitoyl-γ-glutamyl)-des(B30) human insulin; B29-N<sup>ε</sup>-(N-lithocholyl-γ-glutamyl)-des(B30) human insulin; B29-N<sup>ε</sup>-(ω-carboxyheptadecanoyl)-des(B30) human insulin; and B29-N<sup>ε</sup>-(ω-carboxyheptadecanoyl) human insulin.

[00231] The amino acid sequences of various insulin polypeptides are publicly available in, e.g., public databases such as GenBank, journal articles, patents and published patent applications, and the like. For example, the amino acid sequences of human insulin are found in GenBank under the following accession numbers: CAA00714; CAA00713; CAA00712; CAA01254; 1HISA and 1HISB; 1HIQA and 1HIQB; 1HITA and 1HITB; 1HLSA and 1HLSB; 1VKTA and 1VKTB.

[00232] In addition, insulin derivatives and protease-resistant or protease-resistant, hyperglycosylated forms thereof can be used as parent polypeptides and known protease-resistant or protease-resistant, hyperglycosylated polypeptide variants, respectively, in methods and/or compositions of the present invention. Insulin derivatives, include, but not are limited to, acylated insulin, glycosylated insulin, and the like. Examples of acylated insulin include... those disclosed in U.S. Patent No. 5,922,675, e.g., insulin derivatized with a C<sub>6</sub>-C<sub>21</sub> fatty acid (e.g., myristic, pentadecylic, palmitic, heptadecylic, or stearic acid) at an α- or ε-amino acid of glycine, phenylalanine, or lysine.

### Antibodies

[00233] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises an antibody polypeptide amino acid sequence, and further comprises at least one non-native glycosylation site compared to a parent antibody polypeptide; and further comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. Suitable antibodies include, but are not limited to, antibodies of various isotypes (e.g., IgG1, IgG3 and IgG4); monoclonal antibodies produced by any means; humanized antibodies; chimeric antibodies; single-chain antibodies; antibody fragments such as Fv, F(ab')<sub>2</sub>, Fab', Fab, Facb, and the like; and the like, provided that the antibody is capable of binding to antigen. Suitable monoclonal antibodies include antibodies that are specific for a cell surface receptor and that function as

antagonists to the receptor, including, but not limited to, antibody to TGF- $\beta$  receptor, antibody to TNF- $\alpha$  receptor, antibody to VEGF receptor (see, e.g., U.S. Patent Nos. 6,617,160, 6,448,077, and 6,365,157), antibody to epidermal growth factor receptor, and the like; antibodies specific for receptor ligands, including, but not limited to, antibody to TGF- $\beta$ , antibody to TNF- $\alpha$ , antibody to VEGF, and the like; antibody specific for a tumor-associated antigen; antibody specific for CD20; antibody specific for epidermal growth factor receptor-2; antibody specific for the receptor binding domain of IgE; antibody specific for adhesion molecules (e.g., antibody specific for  $\alpha$  subunit (CD11a) of LFA-1; antibody specific for  $\alpha 4\beta 7$ ; etc.); and the like.

#### **Blood factors**

[00234] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a blood factor polypeptide amino acid sequence, and further comprises at least one non-native glycosylation site compared to a parent blood factor polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in a parent polypeptide. Suitable blood factor polypeptides include, but are not limited to, a tissue plasminogen activator (TPA); Factor VIIa; Factor VIII; Factor IX;  $\beta$ -globin; hemoglobin; and the like. The amino acid sequences of various blood factors are publicly available, e.g., in public databases such as GenBank; journal articles; patents and published patent applications; and the like. For example, the amino acid sequences of human TPA are found under GenBank Accession Nos. P0070, NP\_127509, and NP-000921; the amino acid sequence of a human Factor VIIa is found under GenBank Accession No. KFHU7; the amino acid sequence of a human Factor IX is found under GenBank Accession Nos. P00740 and NP\_000124; the amino acid sequence of a human Factor VIII is found under GenBank Accession Nos. AAH64380, AAH22513, and P00451.

[00235] In one aspect, the parent polypeptide is ACTIVASE® alteplase and the protease-resistant, polypeptide variant is a protease-resistant variant of TNKase™ tenecteplase.

#### **Colony stimulating factors**

[00236] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a colony stimulating factor polypeptide amino acid sequence, and further comprises at least one non-native glycosylation site compared to a parent colony stimulating factor polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. Suitable colony stimulating factor polypeptides include, but are not limited to, granulocyte colony stimulating factor (G-CSF), such as NEUPOGEN® filgrastim and

NEULASTA™ pegfilgrastim, granulocyte-monocyte colony stimulating factor (GM-CSF), such as LEUKINE® sargramostim, macrophage colony stimulating factor, megakaryocyte colony stimulating factor; IL-3; stem cell factor (SCF); and the like.

[00237] The amino acid sequences of various blood factors are publicly available, e.g., in public databases such as GenBank; journal articles; patents and published patent applications; and the like. For example, amino acid sequences of IL-3 are disclosed in U.S. Pat. Nos. 4,877,729 and 4,959,455, and International Patent Publication No. WO 88/00598; amino acid sequences of human G-CSF are disclosed in U.S. Pat. No. 4,810,643; WO 91/02754 and WO 92/04455 disclose the amino acid sequence of fusion proteins comprising IL-3; WO 95/21197, WO 95/21254, and U.S. Patent No. 6,730,303 disclose fusion proteins capable of broad multi-functional hematopoietic properties; amino acid sequences of human G-CSF are found under GenBank Accession Nos. NP\_757374, P09919, FQHUGL, and NP\_000750; amino acid sequences of human GM-CSF are found under GenBank Accession Nos. NP\_000749 and P04141; amino acid sequences of IL-3 are found under GenBank Accession Nos. AAH66272, AAH66273, and AAH66276; etc.

#### **Growth hormones**

[00238] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a growth hormone polypeptide amino acid sequence, and further comprises at least one non-native glycosylation site compared to a parent growth hormone polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. Suitable growth hormone polypeptides include, but are not limited to, somatotropin; a human growth hormone; any of the growth hormone variants disclosed in U.S. Patent Nos. 6,143,523, 6,136,563, 6,022,711, and 5,688,666; fusion proteins comprising a growth hormone, e.g., as disclosed in U.S. Patent No. 5,889,144; growth hormone fragments that retain growth hormone activity; a growth hormone receptor polypeptide agonist as disclosed in U.S. Patent No. 6,387,879; and the like. Growth hormones include alternative forms of known growth hormones, e.g., alternative forms of human growth hormone (hGH), including naturally-occurring derivatives, variants and metabolic products, degradation products primarily of biosynthetic hGH and engineered variants of hGH produced by recombinant methods (see, e.g., U.S. Patent No. 6,348,444).

#### **Growth factors**

[00239] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a growth factor amino acid sequence

comprising at least one non-native glycosylation site compared to a parent growth hormone polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. Suitable growth factor polypeptides include, but are not limited to, keratinocyte growth factor; an acidic fibroblast growth factor, a stem cell factor, a basic fibroblast growth factor, a hepatocyte growth factor, an insulin-like growth factor, etc.; active fragments of a growth factor; fusion proteins comprising a growth factor; and the like. The amino acid sequences of various growth factors are publicly available, e.g., in public databases such as GenBank; journal articles; patents and published patent applications; and the like. For example, amino acid sequences of bFGF are found under GenBank Accession Nos. AAB20640, AAA57275, A43498, and AAB20639; amino acid sequences of aFGF are found under GenBank Accession Nos. AAB29059, CAA46661, and 1605206A; amino acid sequences of stem cell factor are found under GenBank Accession Nos. AAH69733, AAH69783, and AAH69797; amino acid sequences of keratinocyte growth factor are found under GenBank Accession Nos. O35565, AAL05875, and P21781; amino acid sequences of hepatocyte growth factor are found under GenBank Accession Nos. AAA64239, AAB20169, and CAA40802.

#### **Soluble receptors**

[00240] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a soluble receptor polypeptide amino acid sequence, and further comprises at least one non-native glycosylation site compared to a parent soluble receptor polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. Suitable soluble receptor polypeptides include, but are not limited to, a TNF- $\alpha$ -binding soluble receptor; a soluble VEGF receptor; a soluble interleukin receptor; a soluble IL-1 receptor; a soluble type II IL-1 receptor; a soluble  $\gamma/\delta$  T cell receptor; ligand-binding fragments of a soluble receptor; and the like. Suitable soluble receptors bind a ligand that, under normal physiological conditions, binds to and activates the corresponding membrane-bound or cell surface receptor. Thus, a suitable soluble receptor is one that functions as a receptor antagonist, by binding the ligand that would ordinarily bind the receptor in its native (e.g., membrane-bound) form.

[00241] The amino acid sequences of various soluble receptors are publicly available, e.g., in public databases such as GenBank; journal articles; patents and published patent applications; and the like. For example, amino acid sequences of soluble VEGF receptors are found under GenBank Accession Nos. AAC50060 and NP\_002010; soluble VEGF receptors are described in U.S. Patent Nos. 6,383,486, 6,375,929, and 6,100,071; soluble IL-4 receptors are described

in U.S. Pat. No. 5,599,905; soluble IL-1 receptors are described in U.S. Patent Publication No. 20040023869; etc.

### **Chemokines**

[00242] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a chemokine polypeptide amino acid sequence, and further comprises at least one non-native glycosylation site compared to a parent chemokine polypeptide; and further comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. Suitable chemokine polypeptides include, but are not limited to, IP-10; Mig; Gro $\alpha$ /IL-8, RANTES; MIP-1 $\alpha$ ; MIP-1 $\beta$ ; MCP-1; PF-4; and the like; as well as fusion proteins comprising a chemokine. The amino acid sequences of various chemokines are publicly available, e.g., in public databases such as GenBank; journal articles; patents and published patent applications; and the like. For example, amino acid sequences of IP-10 are disclosed in U.S. Patent Nos. 6,491,906, 5,935,567, 6,153,600, 5,728,377, and 5,994,292; amino acid sequences of Mig are disclosed in U.S. Patent No. 6,491,906, and Farber (1993) Biochemical and Biophysical Research Communications 192(1):223-230; amino acid sequences of RANTES are disclosed in U.S. Patent Nos. 6,709,649, 6,168,784, and 5,965,697; etc.

### **Angiogenic agents**

[00243] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises an angiogenic polypeptide amino acid sequence, and further comprises at least one non-native glycosylation site compared to a parent angiogenic polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. Suitable angiogenic polypeptides include, but are not limited to, VEGF polypeptides, including VEGF<sub>121</sub>, VEGF<sub>165</sub>, VEGF-C, VEGF-2, etc.; transforming growth factor-beta; basic fibroblast growth factor; glioma-derived growth factor; angiogenin; angiogenin-2; and the like. The amino acid sequences of various angiogenic agents are publicly available, e.g., in public databases such as GenBank; journal articles; patents and published patent applications; and the like. For example, amino acid sequences of VEGF polypeptides are disclosed in U.S. Patent Nos. 5,194,596, 5,332,671, 5,240,848, 6,475,796, 6,485,942, and 6,057,428; amino acid sequences of VEGF-2 polypeptides are disclosed in U.S. Patent Nos. 5,726,152 and 6,608,182; amino acid sequences of glioma-derived growth factors having angiogenic activity are disclosed in U.S. Patent Nos. 5,338,840 and 5,532,343; amino acid sequences of angiogenin are found

under GenBank Accession Nos. AAA72611, AAA51678, AAA02369, AAL67710, AAL67711, AAL67712, AAL67713, and AAL67714; etc.

#### **Neuroactive peptides**

[00244] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a neuroactive polypeptide amino acid sequence, and further comprises at least one non-native glycosylation site compared to a parent neuroactive polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. Suitable neuroactive polypeptides include, but are not limited to, nerve growth factor, bradykinin, cholecystokinin, gastrin, secretin, oxytocin, gonadotropin-releasing hormone, beta-endorphin, enkephalin, substance P, somatostatin, prolactin, galanin, growth hormone-releasing hormone, bombesin, dynorphin, neurotensin, motilin, thyrotropin, neuropeptide Y, luteinizing hormone, calcitonin, insulin, glucagons, vasopressin, angiotensin II, thyrotropin-releasing hormone, vasoactive intestinal peptide, a sleep peptide, etc.

#### **Additional proteins**

[00245] In its broadest sense, the compositions and methods of the invention contemplate the use of any known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant that comprises an amino acid sequence derived from a parent polypeptide of pharmacologic interest; and that further comprises at least one non-native glycosylation site compared to the parent polypeptide; and that further comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. Other proteins of pharmacologic interest include, but are not limited to, a thrombolytic agent, an atrial natriuretic peptide, bone morphogenic protein, thrombopoietin, glial fibrillary acidic protein, follicle stimulating hormone, a human alpha-1 antitrypsin, a leukemia inhibitory factor, a transforming growth factor, an insulin-like growth factor, a luteinizing hormone, a macrophage activating factor, tumor necrosis factor, a neutrophil chemotactic factor, a nerve growth factor, a tissue inhibitor of metalloproteinases; a vasoactive intestinal peptide, angiotropin, fibrin; hirudin; a leukemia inhibitory factor; and the like. The amino acid sequences of various therapeutic proteins are publicly available, e.g., in public databases such as GenBank; journal articles; patents and published patent applications; and the like. For example, amino acid sequences of tissue plasminogen activator are found under GenBank Accession Nos. P00750, AAA01895, AAA01378, AAB06956, and CAA00642.

[00246] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a relaxin amino acid sequence, and further

comprises at least one non-native glycosylation site compared to a parent relaxin polypeptide; and further comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. The relaxin polypeptide can be a naturally-occurring relaxin or a synthetic relaxin. Naturally occurring biologically active relaxin may be derived from human, murine (i.e., rat or mouse), porcine, or other mammalian sources. The term "relaxin" encompasses human H1 preprorelaxin, prorelaxin, and relaxin; H2 preprorelaxin, prorelaxin, and relaxin; recombinant human relaxin (rhRLX); and H3 preprorelaxin, prorelaxin, and relaxin. H3 relaxin has been described in the art. See, e.g., Sudo et al. (2003) *J Biol Chem.* 7;278(10):7855-62. The amino acid sequences of human relaxin are described in the art. For example, human relaxin amino acid sequences are found under the following GenBank Accession Nos.: Q3WXF3, human H3 prorelaxin; P04808, human H1 prorelaxin; NP\_604390 and NP\_005050, human H2 prorelaxin; AAH05956, human relaxin 1 preproprotein; NP\_008842, human H1 preprorelaxin; etc. The relaxin polypeptide can be a relaxin polypeptide comprising A and B chains having N- and/or C-terminal truncations. For example, in H2 relaxin, the A chain can be varied from A(1-24) to A(10-24) and B chain from B(1-33) to B(10-22); and in H1 relaxin, the A chain can be varied from A(1-24) to A(10-24) and B chain from B(1-32) to B(10-22). Also suitable for modification is a relaxin analog having an amino acid sequence which differs from a wild-type (e.g., naturally-occurring) sequence, including, but not limited to, relaxin analogs disclosed in U.S. Patent No. 5,811,395, and U.S. Patent No. 6,200,953. Other suitable relaxins and relaxin formulations are found in U.S. Patent No. 5,945,402. Other possible relaxin polypeptides include relaxin having a replacement of one or more of the natural amino-acids in the B and/or A chains with a different amino acid (including the D-form of a natural amino-acid), including, but not limited to, replacement of the Met moiety at B24 with norleucine (Nle), valine (Val), alanine (Ala), glycine (Gly), serine (Ser), or homoserine (HomoSer). Other possible relaxin polypeptides include relaxin having amino acid substitutions at the B/C and C/A junctions of prorelaxin, which modifications facilitate cleavage of the C chain from prorelaxin; and variant relaxin comprising a non-naturally occurring C peptide, e.g., as described in U.S. Patent No. 5,759,807.

**Protease-resistant or protease-resistant, hyperglycosylated polypeptide variants of parent cytokine polypeptides**

[00247] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a variant of a parent protein therapeutic, and the parent protein therapeutic is a cytokine. In some embodiments, a known protease-resistant or

protease-resistant, hyperglycosylated polypeptide variant comprises one or more of the amino acid replacements, compared to an unmodified parent cytokine, as set forth in an amino acid sequence as depicted in any one of SEQ ID NOs:2-181 (IFN- $\alpha$ 2b variants), 233-289 (IFN- $\beta$  variants), 290-311 (IFN- $\gamma$  variants), 362-400 (GM-CSF variants), 631-662 (G-CSF variants), 850-895 (hGH variants), 940-977 (EPO variants), 978-988 (IFN- $\alpha$  variants), and 989-1302 (IFN- $\beta$  variants); and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide. Exemplary amino acid replacements that generate hyperglycosylation are depicted in Figures 23-30. In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a structural homolog of a protein comprising an amino acid sequence as set forth in any one of SEQ ID NOs:2-181 (IFN- $\alpha$ 2b variants), 233-289 (IFN- $\beta$  variants), 290-311 (IFN- $\gamma$  variants), 362-400 (GM-CSF variants), 631-662 (G-CSF variants), 850-895 (hGH variants), 940-977 (EPO variants), 978-988 (IFN- $\alpha$  variants), and 989-1302 (IFN- $\beta$  variants); and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00248] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises one or more of the amino acid replacements, compared to an unmodified parent cytokine, as set forth in an amino acid sequence as set forth in any one of SEQ ID NOs:87, 89, 90, 93, 96, 101, 103, 107, 124, 979, 980, 983, 984, 986, and 987; and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00249] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a cytokine modified on the basis of 3-dimensional structural homology with any one of SEQ ID NOs:87, 89, 90, 93, 96, 101, 103, 107, 124, 979, 980, 983, 984, 986, and 987 ; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00250] In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is selected from protease-resistant or protease-resistant, hyperglycosylated variants of: interleukin-10 (IL-10), interferon beta (IFN $\beta$ ), interferon alpha-2a (IFN- $\alpha$ 2a), interferon alpha-2b (IFN- $\alpha$ 2b), interferon gamma (IFN- $\gamma$ ), granulocyte colony



stimulating factor (G-CSF), leukemia inhibitory factor (LIF), human growth hormone (hGH), ciliary neurotrophic factor (CNTF), leptin, oncostatin M, interleukin-6 (IL-6), interleukin-12 (IL-12), erythropoietin (EPO), granulocyte-macrophage colony stimulating factor (GM-CSF), interleukin-2 (IL-2), interleukin-3 (IL-3), interleukin-4 (IL-4), interleukin-5 (IL-5), interleukin-13 (IL-13), Flt3 ligand and stem cell factor (SCF). In particular embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is selected from protease-resistant or protease-resistant, hyperglycosylated variants of IFN $\beta$ , IFN- $\alpha$ 2a, IFN- $\alpha$ 2b, IFN- $\gamma$ , G-CSF, hGH, EPO, and GM-CSF. In particular embodiments, the known protease-resistant cytokine variant is an interferon.

[00251] The known protease-resistant or protease-resistant, hyperglycosylated cytokine variant of a parent cytokine exhibits increased resistance to proteolysis compared to the unmodified (parent) cytokine. In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is an interferon variant. In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is an IFN- $\alpha$ 2a variant. In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is an IFN- $\alpha$ 2b variant. In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is an IFN- $\beta$  variant. In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is an IFN- $\gamma$  variant. In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is a variant of a consensus interferon comprising the amino acid sequence identified as SEQ ID NO:232, or as shown in Figure 9, or as depicted in Figure 24.

#### **IFN- $\alpha$ polypeptide variants**

[00252] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises one or more of the mutations shown in Table 1, below, where the amino acid numbering coincides with the amino acid numbering set forth in Figure 1; and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

Table 1

IFN- $\alpha$ LEAD	SEQ ID N°	Mutation(s)
1	983	K121Q / P109A
2	987	E159H / Y89H
3	124	E159Q
4	90	E58H
5	89	E58Q
6	979	E41H / Y89H / N45D
7	103	L117I
8	986	R125H / M111V
9	96	E107H
10	101	E113H
11	87	E41Q
12	107	R125Q
13	985	L117V / A139G
14	980	E41Q / D94G
15	93	E78H
16	984	K133Q / K121Q / P109A / G102R

[00253] In one aspect, the parent polypeptide is IFN- $\alpha$ 2a or IFN- $\alpha$ 2b and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises one or more single amino acid replacements of the IFN- $\alpha$ 2a amino acid sequence depicted in Figure 1 or of the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 2, corresponding to the replacement of: L by V at position 3; L by I at position 3; P by S at position 4; P by A at position 4; R by H at position 12; R by Q at position 12; R by H at position 13; R by Q at position 13; M by V at position 16; M by I at position 16; R by H at position 22; R by Q at position 22; R or K by H at position 23; R or K by Q at position 23; F by I at position 27; F by V at position 27; L by V at position 30; L by I at position 30; K by Q at position 31; K by T at position 31; R by H at position 33; R by Q at position 33; E by Q at position 41; E by H at position 41; K by Q at position 49; K by T at position 49; E by Q at position 58; E by H at position 58; K by Q at position 70; K by T at position 70; E by Q at position 78; E by H at position 78; K by Q at position 83; K by T at position 83; Y by H at position 89; Y by I at position 89; E by Q at position 96; E by H at position 96; E by Q at position 107; E by H at position 107; P by S at position 109; P by A at position 109; L by V at position 110; L by I at position 110; M by V at position 111; M by I at position 111; E by Q at position 113; E by H at position 113; L by V at position 117; L by I at position 117; R by H at position 120; R by Q at position 120; K by Q at position 121; K by T at position 121; R by H at position 125; R by Q at position 125; L by V at position 128; L by I at position 128; K by Q at position 131; K by T at position 131; E by Q at position 132; E by H at position 132; K by Q at position 133; K by T at position 133; K by Q at position 134; K by T at position 134; Y by H at position 135; Y by I at position 135; P by S at

position 137; P by A at position 137; M by V at position 148; M by I at position 148; R by H at position 149; R by Q at position 149; E by Q at position 159; E by H at position 159; L by V at position 161; L by I at position 161; R by H at position 162; R by Q at position 162; K by Q at position 164; K by T at position 164; E by Q at position 165; and E by H at position 165, wherein residue 1 corresponds to residue 1 of the mature IFN- $\alpha$ 2a protein as depicted in Figure 1 or wherein residue 1 corresponds to residue 1 of the mature IFN- $\alpha$ 2b protein as depicted in Figure 2; and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00254] In another aspect, the parent polypeptide is IFN- $\alpha$ 2a or IFN- $\alpha$ 2b, and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises one or more single amino acid replacements of the IFN- $\alpha$ 2a amino acid sequence depicted in Figure 1 or of the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 2, corresponding to: F by V at position 27; R by H at position 33; E by Q at position 41; E by H at position 41; E by Q at position 58; E by H at position 58; E by Q at position 78; E by H at position 78; Y by H at position 89; E by Q at position 107; E by H at position 107; P by A at position 109; L by V at position 110; M by V at position 111; E by Q at position 113; E by H at position 113; L by V at position 117; L by I at position 117; K by Q at position 121; K by T at position 121; R by H at position 125; R by Q at position 125; K by Q at position 133; K by T at position 133; E by Q at position 159 and E by H at position 159, wherein residue 1 corresponds to residue 1 of the mature IFN- $\alpha$ 2a protein as depicted in Figure 1 or wherein residue 1 corresponds to residue 1 of the mature IFN- $\alpha$ 2b protein as depicted in Figure 2; and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00255] In another aspect, the parent polypeptide is IFN- $\alpha$ 2a or IFN- $\alpha$ 2b, and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises one or more sets of dual-amino acid replacements in the IFN- $\alpha$ 2a amino acid sequence depicted in Figure 1, or in the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 2, corresponding to:

[00256] D by N at position 2 and P by S at position 4;

[00257] D by N at position 2 and P by T at position 4;

[00258] L by N at position 3 and Q by S at position 5;

[00259] L by N at position 3 and Q by T at position 5;

[00260] P by N at position 4 and T by S at position 6;

[00261] P by N at position 4 and T by T at position 6;

- [00262] Q by N at position 5 and H by S at position 7;  
[00263] Q by N at position 5 and H by T at position 7;  
[00264] T by N at position 6 and S by S at position 8;  
[00265] T by N at position 6 and S by T at position 8;  
[00266] H by N at position 7 and L by S at position 9;  
[00267] H by N at position 7 and L by T at position 9;  
[00268] S by N at position 8 and G by S at position 10;  
[00269] S by N at position 8 and G by T at position 10;  
[00270] L by N at position 9 and S by S at position 11;  
[00271] L by N at position 9 and S by T at position 11;  
[00272] M by N at position 21 and K by S at position 23;  
[00273] M by N at position 21 and K by T at position 23;  
[00274] R by N at position 22 and I by S at position 24;  
[00275] R by N at position 22 and I by T at position 24;  
[00276] R or K by N at position 23 and S by S at position 25;  
[00277] R or K by N at position 23 and S by T at position 25;  
[00278] I by N at position 24 and L by S at position 26;  
[00279] I by N at position 24 and L by T at position 26;  
[00280] S by N at position 25 and F by S at position 27;  
[00281] S by N at position 25 and F by T at position 27;  
[00282] L by N at position 26 and S by S at position 28;  
[00283] L by N at position 26 and S by T at position 28;  
[00284] S by N at position 28 and L by S at position 30;  
[00285] S by N at position 28 and L by T at position 30;  
[00286] L by N at position 30 and D by S at position 32;  
[00287] L by N at position 30 and D by T at position 32;  
[00288] K by N at position 31 and R by S at position 33;  
[00289] K by N at position 31 and R by T at position 33;  
[00290] D by N at position 32 and H by S at position 34;  
[00291] D by N at position 32 and H by T at position 34;  
[00292] R by N at position 33 and D by S at position 35;  
[00293] R by N at position 33 and D by T at position 35;  
[00294] H by N at position 34 and F by S at position 36;  
[00295] H by N at position 34 and F by T at position 36;

- [00296] D by N at position 35 and G by S at position 37;
- [00297] D by N at position 35 and G by T at position 37;
- [00298] F by N at position 36 and F by S at position 38;
- [00299] F by N at position 36 and F by T at position 38;
- [00300] G by N at position 37 and P by S at position 39;
- [00301] G by N at position 37 and P by T at position 39;
- [00302] F by N at position 38 and Q by S at position 40;
- [00303] F by N at position 38 and Q by T at position 40;
- [00304] P by N at position 39 and E by S at position 41;
- [00305] P by N at position 39 and E by T at position 41;
- [00306] Q by N at position 40 and E by S at position 42;
- [00307] Q by N at position 40 and E by T at position 42;
- [00308] E by N at position 41 and F by S at position 43;
- [00309] E by N at position 41 and F by T at position 43;
- [00310] E by N at position 42 and G by S at position 44;
- [00311] E by N at position 42 and G by T at position 44;
- [00312] F by N at position 43 and N by S at position 45;
- [00313] F by N at position 43 and N by T at position 45;
- [00314] G by N at position 44 and Q by S at position 46;
- [00315] G by N at position 44 and Q by T at position 46;
- [00316] N by N at position 45 and F by S at position 47;
- [00317] N by N at position 45 and F by T at position 47;
- [00318] Q by N at position 46 and Q by S at position 48;
- [00319] Q by N at position 46 and Q by T at position 48;
- [00320] F by N at position 47 and K by S at position 49;
- [00321] F by N at position 47 and K by T at position 49;
- [00322] Q by N at position 48 and A by S at position 50;
- [00323] Q by N at position 48 and A by T at position 50;
- [00324] K by N at position 49 and E by S at position 51;
- [00325] K by N at position 49 and E by T at position 51;
- [00326] A by N at position 50 and T by S at position 52;
- [00327] A by N at position 50 and T by T at position 52;
- [00328] S by N at position 68 and K by S at position 70;
- [00329] S by N at position 68 and K by T at position 70;

- [00330] K by N at position 70 and S by S at position 72;  
[00331] K by N at position 70 and S by T at position 72;  
[00332] A by N at position 75 and D by S at position 77;  
[00333] A by N at position 75 and D by T at position 77;  
[00334] D by N at position 77 and T by S at position 79;  
[00335] D by N at position 77 and T by T at position 79;  
[00336] I by N at position 100 and G by S at position 102;  
[00337] I by N at position 100 and G by T at position 102;  
[00338] Q by N at position 101 and V by S at position 103;  
[00339] Q by N at position 101 and V by T at position 103;  
[00340] G by N at position 102 and G by S at position 104;  
[00341] G by N at position 102 and G by T at position 104;  
[00342] V by N at position 103 and V by S at position 105;  
[00343] V by N at position 103 and V by T at position 105;  
[00344] G by N at position 104 and T by S at position 106;  
[00345] G by N at position 104 and T by T at position 106;  
[00346] V by N at position 105 and E by S at position 107;  
[00347] V by N at position 105 and E by T at position 107;  
[00348] T by N at position 106 and T by S at position 108;  
[00349] T by N at position 106 and T by T at position 108;  
[00350] E by N at position 107 and P by S at position 109;  
[00351] E by N at position 107 and P by T at position 109;  
[00352] T by N at position 108 and I by S at position 110;  
[00353] T by N at position 108 and I by T at position 110;  
[00354] K by N at position 134 and S by S at position 136;  
[00355] K by N at position 134 and S by T at position 136;  
[00356] S by N at position 154 and N by S at position 156;  
[00357] S by N at position 154 and N by T at position 156;  
[00358] T by N at position 155 and L by S at position 157;  
[00359] T by N at position 155 and L by T at position 157;  
[00360] N by N at position 156 and Q by S at position 158;  
[00361] N by N at position 156 and Q by T at position 158;  
[00362] L by N at position 157 and E by S at position 159;  
[00363] L by N at position 157 and E by T at position 159;

[00364] Q by N at position 158 and S by S at position 160;  
 [00365] Q by N at position 158 and S by T at position 160;  
 [00366] E by N at position 159 and L by S at position 161;  
 [00367] E by N at position 159 and L by T at position 161;  
 [00368] S by N at position 160 and R by S at position 162;  
 [00369] S by N at position 160 and R by T at position 162;  
 [00370] L by N at position 161 and S by S at position 163;  
 [00371] L by N at position 161 and S by T at position 163;  
 [00372] R by N at position 162 and K by S at position 164;  
 [00373] R by N at position 162 and K by T at position 164;  
 [00374] S by N at position 163 and E by S at position 165; and  
 [00375] S by N at position 163 and E by T at position 165, wherein residue 1 corresponds to residue 1 of the mature IFN- $\alpha$ 2a depicted in Figure 1, or IFN- $\alpha$ 2b depicted in Figure 2; and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00376] In another aspect, the parent polypeptide is IFN- $\alpha$ 2a or IFN- $\alpha$ 2b, and the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises one or more sets of dual-amino acid replacements in the IFN- $\alpha$ 2a amino acid sequence depicted in Figure 1, or in the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 2, corresponding to:

[00377] Q by N at position 5 and H by S at position 7;  
 [00378] P by N at position 39 and E by S at position 41;  
 [00379] P by N at position 39 and E by T at position 41;  
 [00380] Q by N at position 40 and E by S at position 42;  
 [00381] Q by N at position 40 and E by T at position 42;  
 [00382] E by N at position 41 and F by S at position 43;  
 [00383] E by N at position 41 and F by T at position 43;  
 [00384] F by N at position 43 and N by S at position 45;  
 [00385] G by N at position 44 and Q by T at position 46;  
 [00386] N by N at position 45 and F by S at position 47;  
 [00387] N by N at position 45 and F by T at position 47;  
 [00388] Q by N at position 46 and Q by S at position 48;  
 [00389] F by N at position 47 and K by S at position 49;  
 [00390] F by N at position 47 and K by T at position 49;

[00391] I by N at position 100 and G by S at position 102;  
 [00392] I by N at position 100 and G by T at position 102;  
 [00393] V by N at position 105 and E by S at position 107;  
 [00394] V by N at position 105 and E by T at position 107;  
 [00395] T by N at position 106 and T by S at position 108;  
 [00396] T by N at position 106 and T by T at position 108;  
 [00397] E by N at position 107 and P by S at position 109;  
 [00398] E by N at position 107 and P by T at position 109;  
 [00399] L by N at position 157 and E by S at position 159;  
 [00400] L by N at position 157 and E by T at position 159;  
 [00401] E by N at position 159 and L by S at position 161; and  
 [00402] E by N at position 159 and L by T at position 161, wherein residue 1 corresponds to residue 1 of the mature IFN- $\alpha$ 2a depicted in Figure 1, or IFN- $\alpha$ 2b depicted in Figure 2; and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00403] In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is an IFN- $\alpha$ 2b, IFN- $\alpha$ 2a, or an IFN-2c variant comprising one or more single amino acid replacements corresponding to the replacement of: N by D at position 45; D by G at position 94; G by R at position 102; A by G at position 139; or any combination thereof, where the amino acid numbering is as set forth in Figure 1.

[00404] In some embodiments, a known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is an IFN- $\alpha$ 2b, IFN- $\alpha$ 2a, or an IFN-2c variant comprising one or more single amino acid replacements in any of SEQ ID Nos. 1, 182, 185 or 232 (e.g., in any of the sequences set forth in Figures 2, 1, 11, and 9, respectively) corresponding to the replacement: L by V at position 3; L by I at position 3; P by S at position 4; P by S at position 4; P by A at position 4; R by H at position 12; R by Q at position 12; R by H at position 13; R by Q at position 13; M by V at position 16; M by I at position 16; R by H at position 22; R by Q at position 22; R or K by H at position 23; R or K by Q at position 23; F by I at position 27; F by V at position 27; L by V at position 30; L by I at position 30; K by Q at position 31; K by T at position 31; R by H at position 33; R by Q at position 33; E by Q at position 41; E by H at position 41; K by Q at position 49; K by T at position 49; E by Q at position 58; E by H at position 58; K by Q at position 70; K by T at position 70; E by Q at position 78; E by H at position 78; K by Q at position 83; K by T at position 83; Y by H at position 89; Y by I at



position 89; E by Q at position 96; E by H at position 96; E by Q at position 107; E by H at position 107; P by S at position 109; P by A at position 109; L by V at position 110; L by I at position 110; M by V at position 111; M by I at position 111; E by Q at position 113; E by H at position 113; L by V at position 117; L by I at position 117; R by H at position 120; R by Q at position 120; K by Q at position 121; K by T at position 121; R by H at position 125; R by Q at position 125; L by V at position 128; L by I at position 128; K by Q at position 131; K by T at position 131; E by Q at position 132; E by H at position 132; K by Q at position 133; K by T at position 133; K by Q at position 134; K by T at position 134; Y by H at position 135; Y by I at position 135; P by S at position 137; P by A at position 137; M by V at position 148; M by I at position 148; R by H at position 149; R by Q at position 149; E by Q at position 159; E by H at position 159; L by V at position 161; L by I at position 161; R by H at position 162; R by Q at position 162; K by Q at position 164; K by T at position 164; E by Q at position 165; or E by H at position 165; or any combination thereof, wherein residue 1 corresponds to residue 1 of the mature IFN- $\alpha$ 2b or IFN- $\alpha$ 2a cytokine set forth in SEQ ID NOS:1 or 182 (or as set forth in Figures 2 and 1, respectively); and further comprising an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00405] In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated cytokine variant is an IFN- $\alpha$ 2b, IFN- $\alpha$ 2a, or an IFN-2c variant comprising one or more single amino acid replacements in any of SEQ ID.Nos. 1, 182, 185 or 232 (e.g., in any of the sequences set forth in Figures 2, 1, 11, and 9, respectively) corresponding to the replacement: L by V at position 3; L by I at position 3; P by S at position 4; P by A at position 4; R by H at position 12; R by Q at position 12; R by H at position 13; R by Q at position 13; M by V at position 16; M by I at position 16; R by H at position 22; R by Q at position 22; R or K by H at position 23; R or K by Q at position 23; F by I at position 27; F by V at position 27; L by V at position 30; L by I at position 30; K by Q at position 31; K by T at position 31; R by H at position 33; R by Q at position 33; E by Q at position 41; E by H at position 41; K by Q at position 49; K by T at position 49; E by Q at position 58; E by H at position 58; K by Q at position 70; K by T at position 70; E by Q at position 78; E by H at position 78; K by Q at position 83; K by T at position 83; Y by H at position 89; Y by I at position 89; E by Q at position 96; E by H at position 96; E by Q at position 107; E by H at position 107; P by S at position 109; P by A at position 109; L by V at position 110; L by I at position 110; M by V at position 111; M by I at position 111; E by Q at position 113; E by H at position 113; L by V at position 117; L by I at position 117; R by H at position 120; R by Q at position 120; K by Q at

position 121; K by T at position 121; R by H at position 125; R by Q at position 125; L by V at position 128; L by I at position 128; K by Q at position 131; K by T at position 131; E by Q at position 132; E by H at position 132; K by Q at position 133; K by T at position 133; K by Q at position 134; K by T at position 134; Y by H at position 135; Y by I at position 135; P by S at position 137; P by A at position 137; M by V at position 148; M by I at position 148; R by H at position 149; R by Q at position 149; E by Q at position 159; E by H at position 159; L by V at position 161; L by I at position 161; R by H at position 162; R by Q at position 162; K by Q at position 164; K by T at position 164; E by Q at position 165; E by H at position 165; N by D at position 45; D by G at position 94; G by R at position 102; or A by G at position 139; or any combination thereof, wherein residue 1 corresponds to residue 1 of the mature IFN- $\alpha$ 2b or IFN- $\alpha$ 2a cytokine set forth in SEQ ID No. 1 or 182; and further comprising an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00406] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\alpha$ 2a variants is an [D99N]IFN- $\alpha$ 2a glycopeptide, where the [D99N]IFN- $\alpha$ 2a glycopeptide is a variant of IFN- $\alpha$ 2a having (a) an asparagine residue in place of the native aspartic acid residue at amino acid position 99 in the amino acid sequence of IFN- $\alpha$ 2a (where the amino acid position is as set forth in Figure 24; and corresponds to D71 of the sequence set forth in Figure 1); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue. In some embodiments, the IFN- $\alpha$ 2a sequence has a lysine residue in place of the arginine residue at amino acid position 50 in the IFN- $\alpha$ 2b sequence shown in Figure 24 (corresponding to amino acid position 23 of the IFN- $\alpha$ 2b sequence shown in Figure 2).

[00407] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\alpha$ 2a variants is an [D99N, D105N]IFN- $\alpha$ 2a glycopeptide, where the [D99N, D105N]IFN- $\alpha$ 2a glycopeptide is a variant of IFN- $\alpha$ 2a having (a) an asparagine residue in place of the native aspartic acid residue at each of amino acid positions 99 and 105 in the amino acid sequence of IFN- $\alpha$ 2a (where the amino acid positions are as set forth in Figure 24; and where D99 and D105 in Figure 24 correspond to D71 and D77, respectively, in Figures 1 and 2); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues. In some embodiments, the IFN- $\alpha$ 2a sequence has a lysine residue in place of the arginine residue at amino acid position 50 in the IFN- $\alpha$ 2b sequence shown in Figure 24 (corresponding to Arg 23 in the IFN- $\alpha$ 2b sequence shown in Figure 2).

[00408] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\alpha$ 2b variants is an [D99N]IFN- $\alpha$ 2b glycopeptide, where the [D99N]IFN- $\alpha$ 2b glycopeptide is a variant of IFN- $\alpha$ 2b having (a) an asparagine residue in place of the native aspartic acid residue at amino acid position 99 in the amino acid sequence of IFN- $\alpha$ 2b depicted in **Figure 24** (where the amino acid position is as set forth in Figure 24; and where D99 in Figure 24 corresponds to D71 in Figures 1 and 2); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.

[00409] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\alpha$ 2b variants is an [D99N, D105N]IFN- $\alpha$ 2b glycopeptide, where the [D99N, D105N]IFN- $\alpha$ 2b glycopeptide is a variant of IFN- $\alpha$ 2b having (a) an asparagine residue in place of the native aspartic acid residue at each of amino acid positions 99 and 105 in the amino acid sequence of IFN- $\alpha$ 2b depicted in **Figure 24** (where the amino acid positions are as set forth in Figure 24; and where D99 and D105 in Figure 24 correspond to D71 and D77, respectively, in Figures 1 and 2); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

[00410] In another aspect, any of the aforementioned protease-resistant or protease-resistant, hyperglycosylated IFN- $\alpha$ 2a or IFN- $\alpha$ 2b polypeptide variants further comprises one or more pseudo-wild type mutations. In particular embodiments, any of the aforementioned protease-resistant or protease-resistant, hyperglycosylated IFN- $\alpha$ 2a polypeptide variants further comprises one or more pseudo-wild type mutations at one or more of amino acid residues 9, 10, 17, 20, 24, 25, 35, 37, 41, 52, 54, 56, 57, 58, 60, 63, 64, 65, 76, 89, and 90 as depicted in Figure 1, wherein the mutation(s) are one or more of an insertion, a deletion, and a replacement of the native amino acid residue. In other particular embodiments, any of the aforementioned protease-resistant or protease-resistant, hyperglycosylated IFN- $\alpha$ 2b polypeptide variants further comprises one or more pseudo-wild type mutations at one or more of amino acid residues 9, 10, 17, 20, 24, 25, 35, 37, 41, 52, 54, 56, 57, 58, 60, 63, 64, 65, 76, 89, and 90 as depicted in Figure 2, wherein the mutation(s) are one or more of an insertion, a deletion, and a replacement of the native amino acid residue.

[00411] Exemplary pseudo-wild type replacements are one or more mutations in the IFN- $\alpha$ 2a amino acid sequence depicted in Figure 1, or the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 2, corresponding to: P by A at position 4; Q by A at position 5, T by A at position 6; L by A at position 9, LG by A at position 10; L by A at position 17, Q by A at position 20; I by A at position 24, S by A at position 25; D by A at position 35, G by A at position 37; G by A at position 39; E by A at position 41; E by A at position 42 E by A at position 51; T by A at

position 52, P by A at position 54; V by A at position 55 L by A at position 56; H by A at position 57, E by A at position 58; I by A at position 60, I by A at position 63; F by A at position 64, N by A at position 65; W by A at position 76, D by A at position 77; E by A at position 78 L by A at position 81; Y by A at position 85 Y by A at position 89; Q by A at position 90 G by A at position 104; L by A at position 110 S by A at position 115 and E by A at position 146.

[00412] In another aspect, any of the aforementioned protease-resistant or protease-resistant, hyperglycosylated IFN- $\alpha$ 2a or IFN- $\alpha$ 2b polypeptide variants further comprises one or more pseudo-wild type mutations. In particular embodiments, any of the aforementioned protease-resistant IFN- $\alpha$ 2a polypeptide variants further comprises one or more pseudo-wild type mutations at one or more of amino acid residues 4, 5, 6, 9, 10, 17, 20, 24, 25, 35, 37, 39, 41, 42, 51, 52, 54, 56, 57, 58, 60, 63, 64, 65, 76, 77, 78, 81, 85, 89, 90, 104, 110, 115 and 146 as depicted in Figure 1, wherein the mutation(s) are one or more of an insertion, a deletion, and a replacement of the native amino acid residue. In other particular embodiments, any of the aforementioned protease-resistant or protease-resistant, hyperglycosylated IFN- $\alpha$ 2b polypeptide variants further comprises one or more pseudo-wild type mutations at one or more of amino acid residues 4, 5, 6, 9, 10, 17, 20, 24, 25, 35, 37, 39, 41, 42, 51, 52, 54, 56, 57, 58, 60, 63, 64, 65, 76, 77, 78, 81, 85, 89, 90, 104, 110, 115 and 146 as depicted in Figure 2, wherein the mutation(s) are one or more of an insertion, a deletion, and a replacement of the native amino acid residue.

[00413] Exemplary pseudo-wild type replacements are one or more mutations in the IFN- $\alpha$ 2a amino acid sequence depicted in Figure 1, or the IFN- $\alpha$ 2b amino acid sequence depicted in Figure 2, corresponding to: P by A at position 4; Q by A at position 5; T by A at position 6; L by A at position 9; LG by A at position 10; L by A at position 17; Q by A at position 20; I by A at position 24; S by A at position 25; D by A at position 35; G by A at position 37; G by A at position 39; E by A at position 41; E by A at position 42; E by A at position 51; T by A at position 52; P by A at position 54; V by A at position 55; L by A at position 56; H by A at position 57; E by A at position 58; I by A at position 60; I by A at position 63; F by A at position 64; N by A at position 65; W by A at position 76; D by A at position 77; E by A at position 78; L by A at position 81; Y by A at position 85; Y by A at position 89, Q by A at position 90; G by A at position 104; L by A at position 110; S by A at position 115 and E by A at position 146.

[00414] In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a variant of a parent cytokine that exhibits anti-viral

activity. In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated anti-viral cytokine (e.g., a protease-resistant or protease-resistant, hyperglycosylated variant of IFN- $\alpha$ 2a polypeptide, an IFN- $\alpha$ 2b polypeptide, an IFN- $\gamma$  polypeptide) exhibits at least about 10%, at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, or up to about 100% retention of the antiviral activity when compared to the corresponding unmodified (parent) cytokine (e.g., when compared to the parent IFN- $\alpha$ 2a polypeptide, an IFN- $\alpha$ 2b polypeptide, or IFN- $\gamma$  polypeptide).

[00415] Antiviral activity is readily detected using any known assay. For example, the antiviral activity of an IFN- $\alpha$ 2a polypeptide is tested *in vitro* in the following manner. An interferon-sensitive HeLa cell line (e.g., ATCC accession no. CCL-2) is contacted *in vitro* with an IFN- $\alpha$ 2a polypeptide; subsequently, the cells are contacted with encephalomyocarditis virus (EMCV). Antiviral activity is detected by assessing cytopathic effect (CPE); or by measuring the amount of EMCV mRNA in extracts of infected cells using reverse transcription-polymerase chain reaction (RT-PCR).

[00416] The assay can be quantitative. For example, in some embodiments, the antiviral activity is assessed by reverse transcription quantitative polymerase chain reaction (RT-qPCR). For example, confluent cells (e.g., ATCC accession no. CCL-2) are plated at a density of  $2 \times 10^4$  cells/well in a suitable culture medium (e.g., DMEM 5% SVF medium). Cells are then incubated with IFN- $\alpha$ 2b at a concentration of 500 U/ml for 24 hours at 37°C. After the 24-hour incubation with IFN- $\alpha$ 2b, the cells are challenged with EMCV (MOI = 100). After incubation with virus for 16 hours, or when virus-induced CPE is near maximum in control cells not treated with IFN- $\alpha$ 2b, the number of EMCV particles in each well is determined by RT-PCR quantification of EMCV mRNA in cell lysates. RNA is purified from the cell lysates. See, e.g., U.S. Patent Publication No. 2004/0132977.

[00417] In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is effective in reducing viral load in an individual. Viral load can be measured by measuring the titer or level of virus in serum. These methods include, but are not limited to, a quantitative polymerase chain reaction (PCR) and a branched DNA (bDNA) test. Quantitative assays for measuring the viral load (titer) of HCV RNA have been developed. Many such assays are available commercially, including a quantitative reverse transcription PCR (RT-PCR) (Amplicor HCV Monitor™, Roche Molecular Systems, New Jersey); and a branched DNA (deoxyribonucleic acid) signal amplification assay (Quantiplex™ HCV RNA Assay (bDNA), Chiron Corp., Emeryville, California). See, e.g.,

Gretch et al. (1995) *Ann. Intern. Med.* 123:321-329. Also of interest is a nucleic acid test (NAT), developed by Gen-Probe Inc. (San Diego) and Chiron Corporation, and sold by Chiron Corporation under the trade name Procleix®, which NAT simultaneously tests for the presence of HIV-1 and HCV. See, e.g., Vargo et al. (2002) *Transfusion* 42:876-885.

[00418] In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated anti-viral cytokine variant (e.g., a protease-resistant variant of IFN- $\alpha$ 2a polypeptide, an IFN- $\alpha$ 2b polypeptide, an IFN- $\gamma$  polypeptide) exhibits retention of anti-proliferative activity compared to the unmodified (parent) cytokine protein therapeutic.

[00419] Anti-proliferative activity can be measured using any known method. For example, anti-proliferative activity is assessed by measuring cell proliferation in the presence of the protease-resistant anti-viral cytokine variant, where cell proliferation is measured using any convenient assay. Cell proliferation is measured using assays based on  $^3\text{H}$ -thymidine incorporation; incorporation of the thymidine analog BrdU; cleavage of a tetrazolium salt; DNA-dye complex formation; and the like. One non-limiting example of a suitable assay for cell proliferation is The CellTiter 96® AQueous Non-Radioactive Cell Proliferation Assay (Promega). The CellTiter 96® Aqueous assay is a colorimetric method for determining the number of viable cells in proliferation or chemosensitivity assays. The CellTiter 96® AQueous Assay is composed of solutions of a tetrazolium compound (3-(4,5-dimethylthiazol-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-sulfophenyl)-2H-tetrazolium, inner salt; MTS) and an electron coupling reagent (phenazine methosulfate; PMS). MTS is bio-reduced by cells into a formazan product that is soluble in tissue culture medium. The absorbance of the formazan at 490nm can be measured directly from 96 well assay plates without additional processing. The conversion of MTS into aqueous, soluble formazan is accomplished by dehydrogenase enzymes found in metabolically active cells. The quantity of formazan product as measured by the amount of 490nm absorbance is directly proportional to the number of living cells in culture.

[00420] In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated anti-viral cytokine variant (e.g., a hyperglycosylated, protease-resistant variant of IFN- $\alpha$ 2a polypeptide, an IFN- $\alpha$ 2b polypeptide, an IFN- $\gamma$  polypeptide) binds to an interferon receptor, but exhibits decreased antiviral activity compared to the unmodified (parent) cytokine protein therapeutic, or exhibits decreased anti-proliferative activity, compared to the parent cytokine protein therapeutic.

[00421] In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated anti-viral cytokine variant (e.g., a protease-resistant variant of IFN- $\alpha$ 2a polypeptide, an IFN- $\alpha$ 2b polypeptide, an IFN- $\gamma$  polypeptide) comprises two or more mutations,

e.g., the protease-resistant anti-viral cytokine variant comprises two, three, four, five, six, seven, eight, nine, or ten single amino acid changes compared to the corresponding parent cytokine. In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated anti-viral cytokine variant is a variant of an IFN- $\alpha$ 2a polypeptide. In other embodiments, the known protease-resistant or protease-resistant, hyperglycosylated anti-viral cytokine variant is a variant of an IFN- $\alpha$ 2a polypeptide. In other embodiments, the known protease-resistant or protease-resistant, hyperglycosylated anti-viral cytokine variant is a variant of an IFN- $\gamma$  polypeptide.

[00422] In some embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide cytokine variant comprises an amino acid sequence as set forth in any one of SEQ ID NOs:2-181, where the arginine at position 23 is replaced with a lysine; and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide. In other embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide cytokine variant exhibits greater resistance to proteolysis compared to the unmodified (parent) cytokine, and the protease-resistant or protease-resistant, hyperglycosylated polypeptide cytokine variant comprises one or more amino acid replacements at one or more positions on the cytokine, corresponding to a structurally-related modified amino acid position within the 3-D structure of a IFN- $\alpha$ 2a polypeptide, a IFN- $\alpha$ 2b polypeptide, a IFN- $\alpha$ 2c polypeptide, or a consensus IFN- $\alpha$  as depicted in Figure 9. In some embodiments, resistance to proteolysis is measured by contacting the polypeptide variant *in vitro*, as described above. In other embodiments, resistance to proteolysis is measured by contacting the polypeptide variant *in vitro* or *in vivo* with blood (e.g., human blood). In other embodiments, resistance to proteolysis is measured by contacting the polypeptide variant *in vitro* with serum (e.g., human serum), as described above.

[00423] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated polypeptide IFN- $\alpha$ 2b variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity to either inhibit viral replication or to inhibit cell proliferation in appropriate cells, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00424] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated polypeptide IFN- $\alpha$ 2b variants has increased biological activity compared to the unmodified (parent) cytokine, where the activity is assessed by the capacity to

either inhibit viral replication in appropriate cells, or to inhibit cell proliferation in appropriate cells, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00425] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated polypeptide IFN- $\alpha$ 2a variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity to either inhibit viral replication or to inhibit cell proliferation in appropriate cells, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00426] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated polypeptide IFN- $\alpha$ 2a variants has increased biological activity compared to the unmodified (parent) cytokine, where the activity is assessed by the capacity to either inhibit viral replication in appropriate cells, or to inhibit cell proliferation in appropriate cells, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00427] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated polypeptide IFN- $\alpha$ 2c variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00428] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated polypeptide IFN- $\alpha$ 2c variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

### 3-D structural homologs

[00429] In some embodiments, a hyperglycosylated, protease-resistant polypeptide variant is a modified cytokine. In some embodiments, a hyperglycosylated, protease-resistant cytokine variant is a modified interferon. In some embodiments, any of the above-described hyperglycosylated, protease-resistant cytokine variants that is a structural homolog of IFN- $\alpha$ 2b comprises one or more amino acid replacements at positions corresponding to the 3--dimensional-structurally-similar modified positions within the 3-D structure of the modified IFN- $\alpha$ 2b, IFN- $\alpha$ 2a, IFN- $\alpha$ 2c, or a consensus IFN- $\alpha$  as depicted in Figure 9. In some embodiments, the structural homolog has increased resistance to proteolysis compared to its unmodified (parent) cytokine counterpart, where the resistance to proteolysis is measured by



mixture with a protease *in vitro*, incubation with blood or incubation with serum, as described above.

[00430] In some embodiments, the hyperglycosylated, protease-resistant cytokine variant is a structural homolog of an IFN- $\alpha$  cytokine. In some embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a structural homolog of IFN- $\alpha$ 2b. In some of these embodiments, the IFN- $\alpha$  cytokine is selected from variants of IFN- $\alpha$ 2a, IFN- $\alpha$ 2c, IFN- $\alpha$ c, IFN- $\alpha$ d, IFN- $\alpha$ 5, IFN- $\alpha$ 6, IFN- $\alpha$ 4, IFN- $\alpha$ 4b, IFN- $\alpha$ I, IFN- $\alpha$ J, IFN- $\alpha$ H, IFN- $\alpha$ F, IFN- $\alpha$ 8, and a consensus IFN- $\alpha$ . Thus, in some embodiments, the known hyperglycosylated, protease-resistant IFN- $\alpha$  variant comprises one or more amino acid replacements at one or more target positions in the amino acid sequence of IFN- $\alpha$ 2a, IFN- $\alpha$ 2c, IFN- $\alpha$ c, IFN- $\alpha$ d, IFN- $\alpha$ 5, IFN- $\alpha$ 6, IFN- $\alpha$ 4, IFN- $\alpha$ 4b, IFN- $\alpha$ I, IFN- $\alpha$ J, IFN- $\alpha$ H, IFN- $\alpha$ F, IFN- $\alpha$ 8, or a consensus IFN- $\alpha$ , corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of the IFN- $\alpha$ 2b modified proteins described above. The replacements lead to greater resistance to proteases, as assessed by incubation with a protease or a with a blood lysate or by incubation with serum, compared to the unmodified (parent) IFN- $\alpha$ , e.g., compared to a parent IFN- $\alpha$ 2a, or IFN- $\alpha$ 2b polypeptide.

[00431] In some embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ 2a cytokine, comprising one or more amino acid replacements at one or more target positions in the amino acid sequence set forth in Figure 1 (or SEQ ID NO:182) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ 2a.

[00432] In some embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$ 2a variant comprises one or more single amino acid replacements at one or more target positions in SEQ ID NO: 182 (or the amino acid sequence set forth in Figure 1), corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159; and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00433] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ c cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:183 (as set forth in Figure 10) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases,

as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ c. In some of these embodiments, the modified IFN- $\alpha$ c is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 183 (as set forth in Figure 10), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00434] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ 2c cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:185 (as set forth in Figure 11) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ 2c. In some of these embodiments, the modified IFN- $\alpha$ 2c is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 185 (as set forth in Figure 11), corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00435] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 2c variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 2c variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00436] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ d cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:186 (as set forth in Figure 12) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described

IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ d. In some of these embodiments, the modified IFN- $\alpha$ d is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 186 (as set forth in Figure 12), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00437] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ d variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ d variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00438] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ 5 cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:187 (as set forth in Figure 13) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ 5. In some of these embodiments, the modified IFN- $\alpha$ 5 is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 187 (as set forth in Figure 13), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00439] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 5 variants has increased stability compared to the unmodified (parent) cytokine, where

the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 5 variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00440] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ 6 cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:188 (as set forth in Figure 14) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ 6. In some of these embodiments, the modified IFN- $\alpha$ 6 is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 188 (as set forth in Figure 14), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00441] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 6 variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 6 variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00442] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  polypeptide variant is a modified IFN- $\alpha$ 4 cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:189 (as set forth in Figure 15) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by

incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ 4. In some of these embodiments, the modified IFN- $\alpha$ 4 is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 189 (as set forth in Figure 15), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00443] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 4 variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 4 variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00444] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ 4b cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO: 190 (as set forth in Figure 16) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ 4b. In some of these embodiments, the modified IFN- $\alpha$ 4b is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 190 (as set forth in Figure 16), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00445] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 4b variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other

embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 4b variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00446] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ I cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:191 (as set forth in Figure 17) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ I. In some of these embodiments, the modified IFN- $\alpha$ I is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 191 (as set forth in Figure 17), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00447] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ I variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ I variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00448] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ J cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:192 (as set forth in Figure 18) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ J. In some of these embodiments, the modified IFN- $\alpha$ J is selected from among proteins comprising one or more single amino acid

replacements at one or more target positions in SEQ ID NO: 192 (as set forth in Figure 18), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00449] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ J variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ J variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00450] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ H cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:193 (as set forth in Figure 19) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ H. In some of these embodiments, the modified IFN- $\alpha$ H is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 193 (as set forth in Figure 19), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00451] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ H variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ H variants has increased biological activity compared to the unmodified (parent) cytokine, after

incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00452] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ F cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:194 (as set forth in Figure 20) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ F. In some of these embodiments, the modified IFN- $\alpha$ F is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 194 (as set forth in Figure 20), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00453] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ F variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ F variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00454] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified IFN- $\alpha$ 8 cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:195 (as set forth in Figure 21) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\alpha$ 8. In some of these embodiments, the modified IFN- $\alpha$ 8 is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 195 (as set forth in Figure 21), corresponding to any of amino acid positions: 41, 59, 79, 108, 118, 126, 134 and 160, or to any



of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00455] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 8 variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\alpha$ 8 variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

*Consensus IFN- $\alpha$  polypeptide variants*

[00456] In other embodiments, the hyperglycosylated, protease-resistant IFN- $\alpha$  variant is a modified consensus IFN- $\alpha$  cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:232 (as set forth in Figure 9) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified consensus IFN- $\alpha$ . In some of these embodiments, the modified consensus IFN- $\alpha$  is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 232 (as set forth in Figure 9), corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159, or to any of amino acid positions: 27, 33, 41, 59, 79, 90, 108, 110, 111, 112, 114, 118, 122, 126, 134, and 160; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00457] In some embodiments, any of the above-described consensus IFN- $\alpha$  variants is an [D99N]interferon alfacon-1 glycopeptide, where the [D99N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 99 in the amino acid sequence of Infergen (interferon alfacon-1) depicted in Figure 24 (where the amino acid position is as set forth in Figure 24; and where D99 in Figure 24 corresponds to D71 in Figure 9); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.

**[00458]** In some embodiments, any of the above-described consensus IFN- $\alpha$  variants is an [D99N, D105N]interferon alfacon-1 glycopeptide, where the [D99N, D105N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid residues at amino acid positions 99 and 105 in the amino acid sequence of Infergen depicted in **Figure 24** (where the amino acid positions are as set forth in Figure 24; and where D99 and D105 in Figure 24 correspond to D71 and D77, respectively, in Figure 9); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

**[00459]** In some embodiments, any of the above-described consensus IFN- $\alpha$  variants is an [D99N, D105N, E134N]interferon alfacon-1 glycopeptide, where the [D99N, D105N, E134N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid, aspartic acid, and glutamic acid residues at amino acid positions 99, 105 and 134, respectively, in the amino acid sequence of Infergen depicted in **Figure 24** (where the amino acid positions are as set forth in Figure 24; and where D99, D105, and E134 in Figure 24 correspond to D71, D77, and E106, respectively, in Figure 9); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

**[00460]** In some embodiments, any of the above-described consensus IFN- $\alpha$  variants is an [D99N, E134N]interferon alfacon-1 glycopeptide, where the [D99N, E134N] interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid and glutamic acid residues at amino acid positions 99 and 134, respectively, in the amino acid sequence of Infergen depicted in **Figure 24** (where the amino acid positions are as set forth in Figure 24; and where D99 and E134 in Figure 24 correspond to D71 and E106, respectively, in Figure 9); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

**[00461]** In some embodiments, any of the above-described consensus IFN- $\alpha$  variants is an [D105N, E134N]interferon alfacon-1 glycopeptide, where the [D105N, E134N] interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid and glutamic acid residues at amino acid positions 105 and 134, respectively, in the amino acid sequence of Infergen depicted in **Figure 24** (where the amino acid positions are as set forth in Figure 24; and where D105 and E134 in Figure 24 correspond to D77 and E106, respectively, in Figure 9); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

[00462] In some embodiments, any of the above-described consensus IFN- $\alpha$  variants is an [D99N, D105N, E134T]interferon alfacon-1 glycopeptide, where the [D99N, D105N, E134T]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid residues at amino acid positions 99 and 105 in the amino acid sequence of Infergen depicted in **Figure 24** (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of Infergen depicted in **Figure 24** (where the amino acid positions are as set forth in Figure 24; and where D99, D105, and E134 in Figure 24 correspond to D71, D77, and E106, respectively, in Figure 9); and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues.

[00463] In some embodiments, any of the above-described consensus IFN- $\alpha$  variants is an [D99N, E134T]interferon alfacon-1 glycopeptide, where the [D99N, E134T]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 99 in the amino acid sequence of Infergen depicted in **Figure 24** (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of Infergen depicted in **Figure 24** (where the amino acid positions are as set forth in Figure 24; and where D99 and E134 in Figure 24 correspond to D71 and E106, respectively, in Figure 9); and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues.

[00464] In some embodiments, any of the above-described consensus IFN- $\alpha$  variants is an [D105N, E134T]interferon alfacon-1 glycopeptide, where the [D105N, E134T]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 105 in the amino acid sequence of Infergen depicted in **Figure 24** (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of Infergen depicted in **Figure 24** (where the amino acid positions are as set forth in Figure 24; and where D105 and E134 in Figure 24 correspond to D77 and E106, respectively, in Figure 9); and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues.

#### *Hybrid Type I Interferon Receptor Polypeptide Agonists*

[00465] As used herein, a "hybrid Type I interferon receptor polypeptide agonist" is a polypeptide having an amino acid sequence comprising discrete sub-sequences corresponding in amino acid identity and number to sub-sequences of different, naturally occurring Type I

interferon receptor polypeptide agonists, wherein the amino acid sequence of the subject polypeptide agonist differs from that of any naturally-occurring Type I interferon receptor polypeptide agonist. In some embodiments, the polypeptide variant is composed of discrete sub-sequences selected from IFN- $\alpha$ 2b, IFN- $\alpha$ 14, IFN- $\beta$ 1, and IFN- $\omega$ , and the amino acid sequence of the polypeptide variant agonist differs from the amino acid sequences of IFN- $\alpha$ 2b, IFN- $\alpha$ 14, IFN- $\beta$ 1, and IFN- $\omega$ . In other embodiments, the polypeptide variant is composed of discrete sub-sequences selected from IFN- $\alpha$ 2b, IFN- $\alpha$ 14, IFN- $\beta$ 1, Infergen® consensus IFN- $\alpha$ , and IFN- $\omega$ , and the amino acid sequence of polypeptide variant differs from the amino acid sequences of IFN- $\alpha$ 2b, IFN- $\alpha$ 14, IFN- $\beta$ 1, Infergen® consensus IFN- $\alpha$ , and IFN- $\omega$ .

[00466] Suitable protease-resistant or protease-resistant, hyperglycosylated polypeptide variants include protease-resistant or protease-resistant, hyperglycosylated forms of any parent hybrid Type I interferon receptor polypeptide agonist. In one aspect, a protease-resistant or protease-resistant, hyperglycosylated variant of a parent hybrid Type I interferon receptor polypeptide agonist has an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00467] In one aspect, the parent hybrid Type I interferon receptor polypeptide agonist is [D99N]IFN- $\alpha$ 2a glycopeptide, where the [D99N]IFN- $\alpha$ 2a glycopeptide is a variant of IFN- $\alpha$ 2a having an asparagine residue in place of the native aspartic acid residue at amino acid position 99 in the amino acid sequence of IFN- $\alpha$ 2a; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is a protease-resistant [D99N, D105N]IFN- $\alpha$ 2a glycopeptide, where the protease-resistant [D99N, D105N]IFN- $\alpha$ 2a glycopeptide is a variant of IFN- $\alpha$ 2a having (a) an asparagine residue in place of the native aspartic acid residue at each of amino acid positions 99 and 105 in the amino acid sequence of IFN- $\alpha$ 2a (where the D99 and D105 amino acid positions are as set forth in Figure 24; and correspond to D71 and D77, respectively, of the amino acid sequence of IFN- $\alpha$ 2a set forth in Figure 1); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide. It will be appreciated that the amino acid sequence of IFN- $\alpha$ 2a is the same as the amino acid sequence of IFN- $\alpha$ 2b depicted in Figure 24, provided that the IFN- $\alpha$ 2a sequence has a lysine residue in place of the arginine residue at amino acid position 50 in the IFN- $\alpha$ 2b sequence shown in Figure 24 (corresponding to R50 of the IFN- $\alpha$ 2b sequence set forth in Figure 2).

[00468] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is [D99N]IFN- $\alpha$ 2b glycopeptide, where the [D99N]IFN- $\alpha$ 2b glycopeptide is a variant of IFN- $\alpha$ 2b having an asparagine residue in place of the native aspartic acid residue at amino acid position 99 in the amino acid sequence of IFN- $\alpha$ 2b depicted in **Figure 24**; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is a protease-resistant [D99N, D105N]IFN- $\alpha$ 2b glycopeptide, where the protease-resistant [D99N, D105N]IFN- $\alpha$ 2b glycopeptide is a variant of IFN- $\alpha$ 2b having (a) an asparagine residue in place of the native aspartic acid residue at each of amino acid positions 99 and 105 in the amino acid sequence of IFN- $\alpha$ 2b depicted in **Figure 24** (where the D99 and D105 amino acid positions are as set forth in **Figure 24**; and corresponds to D71 and D77, respectively, of the amino acid sequence of IFN- $\alpha$ 2b set forth in **Figure 2**); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00469] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the interferon alfacon-1 polypeptide; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is an [D99N]interferon alfacon-1 glycopeptide, where the [D99N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 99 in the amino acid sequence of Infergen depicted in **Figure 24** (where the D99 amino acid position is as set forth in **Figure 24**; and corresponds to D71 of the amino acid sequence of consensus IFN- $\alpha$  set forth in **Figure 9**); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00470] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the interferon alfacon-1 polypeptide; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is an [D99N, D105N]interferon alfacon-1 glycopeptide, where the [D99N, D105N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid residues at amino acid positions 99 and 105 in the amino acid sequence of Infergen depicted in **Figure 24** (where the D99 and D105 amino acid positions are as set forth in **Figure 24**; and correspond to D71 and D77, respectively, of the amino acid sequence of consensus IFN- $\alpha$  set forth in **Figure 9**); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues;

and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00471] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the interferon alfacon-1 polypeptide; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is an [D99N, D105N, E134N]interferon alfacon-1 glycopeptide, where the [D99N, D105N, E134N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid, aspartic acid, and glutamic acid residues at amino acid positions 99, 105 and 134, respectively, in the amino acid sequence of Infergen depicted in **Figure 24** (where the D99, D105, and E134 amino acid positions are as set forth in Figure 24; and correspond to D71, D77, and E106, respectively, of the amino acid sequence of consensus IFN- $\alpha$  set forth in Figure 9); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00472] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the interferon alfacon-1 polypeptide; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is an [D99N, E134N]interferon alfacon-1 glycopeptide, where the [D99N, E134N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid and glutamic acid residues at amino acid positions 99 and 134, respectively, in the amino acid sequence of Infergen depicted in **Figure 24** (where the D99 and E134 amino acid positions are as set forth in Figure 24; and correspond to D71 and E106, respectively, of the amino acid sequence of consensus IFN- $\alpha$  set forth in Figure 9); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00473] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the interferon alfacon-1 polypeptide; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is an [D105N, E134N]interferon alfacon-1 glycopeptide, where the [D105N, E134N]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid and glutamic acid residues at amino acid positions 105 and 134, respectively, in the amino acid sequence of Infergen depicted in **Figure**

24 (where the D105 and E134 amino acid positions are as set forth in Figure 24; and correspond to D77 and E106, respectively, of the amino acid sequence of consensus IFN- $\alpha$  set forth in Figure 9); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00474] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the interferon alfacon-1 polypeptide; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is an [D99N, D105N, E134T]interferon alfacon-1 glycopeptide, where the [D99N, D105N, E134T]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for each of the native aspartic acid residues at amino acid positions 99 and 105 in the amino acid sequence of Infergen depicted in **Figure 24**; (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of Infergen depicted in **Figure 24** (where the D99, D105, and E134 amino acid positions are as set forth in Figure 24; and correspond to D71, D77, and E106, respectively, of the amino acid sequence of consensus IFN- $\alpha$  set forth in Figure 9); and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00475] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the interferon alfacon-1 polypeptide; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is an [D99N, E134T]interferon alfacon-1 glycopeptide, where the [D99N, E134T]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 99 in the amino acid sequence of Infergen depicted in **Figure 24**; (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of Infergen depicted in **Figure 24** (where the D99 and E134 amino acid positions are as set forth in Figure 24; and correspond to D71 and E106, respectively, of the amino acid sequence of consensus IFN- $\alpha$  set forth in Figure 9); and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00476] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the interferon alfacon-1 polypeptide; and the protease-resistant or protease-resistant,

hyperglycosylated polypeptide variant is an [D105N, E134T]interferon alfacon-1 glycopeptide, where the [D105N, E134T]interferon alfacon-1 glycopeptide is a variant of the interferon alfacon-1 polypeptide having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 105 in the amino acid sequence of Infergen depicted in **Figure 24**; (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of Infergen depicted in **Figure 24** (where the D105 and E134 amino acid positions are as set forth in Figure 24; and correspond to D77 and E106, respectively, of the amino acid sequence of consensus IFN- $\alpha$  set forth in Figure 9); and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00477] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the “majority” consensus Type I interferon amino acid sequence depicted in **Figure 24**; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is a [D99N]“majority” consensus Type I interferon glycopeptide, where the [D99N]“majority” consensus Type I interferon glycopeptide is the “majority” amino acid sequence depicted in **Figure 24** having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 99 in the “majority” amino acid sequence and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00478] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the “majority” consensus Type I interferon amino acid sequence depicted in **Figure 24**; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is a [D99N, D105N]“majority” consensus Type I interferon glycopeptide, where the [D99N, D105N]“majority” consensus Type I interferon glycopeptide is the “majority” amino acid sequence depicted in **Figure 24** having (a) an asparagine residue substituted for each of the native aspartic acid residues at amino acid positions 99 and 105 in the “majority” amino acid sequence and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00479] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the “majority” consensus Type I interferon amino acid sequence depicted in **Figure 24**; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent



polypeptide is a [D99N, D105N, E134N]“majority” consensus Type I interferon glycopeptide, where the [D99N, D105N, E134N]“majority” consensus Type I interferon glycopeptide is the “majority” amino acid sequence depicted in **Figure 24** having (a) an asparagine residue substituted for each of the native aspartic acid, aspartic acid, and glutamic acid residues at amino acid positions 99, 105 and 134, respectively, in the “majority” amino acid sequence and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00480] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the “majority” consensus Type I interferon amino acid sequence depicted in **Figure 24**; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is a [D99N, E134N]“majority” consensus Type I interferon glycopeptide, where the [D99N, E134N]“majority” consensus Type I interferon glycopeptide is the “majority” amino acid sequence depicted in **Figure 24** having (a) an asparagine residue substituted for each of the native aspartic acid and glutamic acid residues at amino acid positions 99 and 134, respectively, in the “majority” amino acid sequence (where the amino acid positions are as set forth in **Figure 24**); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00481] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the “majority” consensus Type I interferon amino acid sequence depicted in **Figure 24**; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is a [D105N, E134N]“majority” consensus Type I interferon glycopeptide, where the [D105N, E134N]“majority” consensus Type I interferon glycopeptide is the “majority” amino acid sequence depicted in **Figure 24** having (a) an asparagine residue substituted for each of the native aspartic acid and glutamic acid residues at amino acid positions 105 and 134, respectively, in the “majority” amino acid sequence (where the amino acid positions are as set forth in **Figure 24**); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00482] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the “majority” consensus Type I interferon amino acid sequence depicted in **Figure 24**; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is a [D99N, D105N, E134T]“majority” consensus Type I interferon glycopeptide,

where the [D99N, D105N, E134T]“majority” consensus Type I interferon glycopeptide is the “majority” amino acid sequence depicted in **Figure 24** having (a) an asparagine residue substituted for each of the native aspartic acid residues at amino acid positions 99 and 105 in the “majority” amino acid sequence (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the “majority” amino acid sequence and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00483] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the “majority” consensus Type I interferon amino acid sequence depicted in **Figure 24**; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is a [D99N, E134T]“majority” consensus Type I interferon glycopeptide, where the [D99N, E134T]“majority” consensus Type I interferon glycopeptide is the “majority” amino acid sequence depicted in **Figure 24** having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 99 in the “majority” amino acid sequence (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the “majority” amino acid sequence and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00484] In another aspect, the parent hybrid Type I interferon receptor polypeptide agonist is the “majority” consensus Type I interferon amino acid sequence depicted in **Figure 24**; and the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent polypeptide is a [D105N, E134T]“majority” consensus Type I interferon glycopeptide, where the [D105N, E134T]“majority” consensus Type I interferon glycopeptide is the “majority” amino acid sequence depicted in **Figure 24** having (a) an asparagine residue substituted for the native aspartic acid residue at amino acid position 105 in the “majority” amino acid sequence (b) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the “majority” amino acid sequence (where the amino acid positions are as set forth in **Figure 24**); and (c) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues; and comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent polypeptide.

[00485] The numbering of amino acid replacements (discussed in the context of generating hyperglycosylation variants of the parent protein therapeutic) used to describe the protease-

resistant or protease-resistant, hyperglycosylated polypeptide variants of parent hybrid Type I receptor polypeptide agonists herein coincides with the numbering of amino acids used to depict the Type I interferon amino acid sequences appearing in **Figure 24**.

[00486] In another aspect, a protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent hybrid Type I interferon receptor polypeptide agonist therapeutic differs from the parent hybrid Type I interferon receptor polypeptide agonist therapeutic to the extent that the protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises (1) a carbohydrate moiety covalently attached to a non-native glycosylation site not found in the parent hybrid Type I interferon receptor polypeptide agonist therapeutic and/or (2) a carbohydrate moiety covalently attached to a native glycosylation site found but not glycosylated in the parent hybrid Type I interferon receptor polypeptide agonist therapeutic.

[00487] In some embodiments, any of the above-described hyperglycosylated, protease-resistant consensus IFN- $\alpha$  variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant consensus IFN- $\alpha$  variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

#### **IFN- $\beta$ polypeptide variants**

[00488] In some embodiments, a protease-resistant or protease-resistant, hyperglycosylated cytokine variant is an IFN- $\beta$  variant. In some embodiments, the protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variant comprises one or more single amino acid replacements in SEQ ID NO:196 (or the amino acid sequence as set forth in Figure 3), corresponding to the replacement of one or more of: M by V at position 1, M by I at position 1, M by T at position 1, M by Q at position 1, M by A at position 1, L by V at position 5, L by I at position 5, L by T at position 5, L by Q at position 5, L by H at position 5, L by A at position 5, F by I at position 8, F by V at position 8, L by V at position 9, L by I at position 9, L by T at position 9, L by Q at position 9, L by H at position 9, L by A at position 9, R by H at position 11, R by Q at position 11, F by I at position 15, F by V at position 15, K by Q at position 19, K by T at position 19, K by S at position 19, K by H at position 19, W by S at position 22, W by H at position 22, N by H at position 25, N by S at position 25, N by Q at position 25, R by H position 27, R by Q position 27, L by V at position 28, L by I at position 28, L by T at position

28, L by Q at position 28, L by H at position 28, L by A at position 28, E by Q at position 29, E by H at position 29, Y by H at position 30, Y by I at position 30, L by V at position 32, L by I at position 32, L by T at position 32, L by Q at position 32, L by H at position 32, L by A at position 32, K by Q at position 33, K by T at position 33, K by S at position 33, K by H at position 33, R by H at position 35, R by Q at position 35, M by V at position 36, M by I at position 36, M by T at position 36, M by Q at position 36, M by A at position 36, D by Q at position 39, D by H at position 39, D by G at position 39, E by Q at position 42, E by H at position 42, K by Q at position 45, K by T at position 45, K by S at position 45, K by H at position 45, L by V at position 47, L by I at position 47, L by T at position 47, L by, Q at position 47, L by H at position 47, L by A at position 47, K by Q at position 52, K by T at position 52, K by S at position 52, K by H at position 52, F by I at position 67, F by V at position 67, R by H at position 71, R by Q at position 71, D by Q at position 73, D by H at position 73, D by G at position 73, E by Q at position 81, E by H at position 81, E by Q at position 85, E by H at position 85, Y by H at position 92, Y by I at position 92, K by Q at position 99, K by T at position 99, K by S at position 99, K by H at position 99, E by Q at position 103, E by H at position 103, E by Q at position 104, E by H at position 104, K by Q at position 105, K by T at position 105, K by S at position 105, K by H at position 105, E by Q at position 107, E by H at position 107, K by Q at position 108, K by T at position 108, K by S at position 108, K by H at position 108, E by Q at position 109, E by H at position 109, D by Q at position 110, D by H at position 110, D by G at position 110, F by I at position 111, F by V at position 111, R by H at position 113, R by Q at position 113, L by V at position 116, L by I at position 116, L by T at position 116, L by Q at position 116, L by H at position 116, L by A at position 116, L by V at position 120, L by I at position 120, L by T at position 120, L by Q at position 120, L by H at position 120, L by A at position 120, K by Q at position 123, K by T at position 123, K by S at position 123, K by H at position 123, R by H at position 124, R by Q at position 124, R by H at position 128, R by Q at position 128, L by V at position 130, L by I at position 130, L by T at position 130, L by Q at position 130, L by H at position 130, L by A at position 130, K by Q at position 134, K by T at position 134, K by S at position 134, K by H at position 134, K by Q at position 136, K by T at position 136, K by S at position 136, K by H at position 136, E by Q at position 137, E by H at position 137, Y by H at position 138, Y by I at position 138, R by H at position 152, R by Q at position 152, Y by H at position 155, Y by I at position 155, R by H at position 159, R by Q at position 159, Y by H at position 163, Y by I at position 163, R by H at position 165, R by Q at position 165, M by D at position 1, M by E at position 1, M by K at position 1, M by N at position 1, M by R at position 1, M by S at

position 1, L by D at position 5, L by E at position 5, L by K at position 5, L by N at position 5, L by R at position 5, L by S at position 5, L by D at position 6, L by E at position 6, L by K at position 6, L by N at position 6, L by R at position 6, L by S at position 6, L by Q at position 6, L by T at position 6, F by E at position 8, F by K at position 8, F by R at position 8, F by D at position 8, L by D at position 9, L by E at position 9, L by K at position 9, L by N at position 9, L by R at position 9, L by S at position 9, Q by D at position 10, Q by E at position 10, Q by K at position 10, Q by N at position 10, Q by R at position 10, Q by S at position 10, Q by T at position 10, S by D at position 12, S by E at position 12, S by K at position 12, S by R at position 12, S by D at position 13, S by E at position 13, S by K at position 13, S by R at position 13, S by N at position 13, S by Q at position 13, S by T at position 13, N by D at position 14, N by E at position 14, N by K at position 14, N by Q at position 14, N by R at position 14, N by S at position 14, N by T at position 14, F by D at position 15, F by E at position 15, F by K at position 15, F by R at position 15, Q by D at position 16, Q by E at position 16, Q by K at position 16, Q by N at position 16, Q by R at position 16, Q by S at position 16, Q by T at position 16, C by D at position 17, C by E at position 17, C by K at position 17, C by N at position 17, C by Q at position 17, C by R at position 17, C by S at position 17, C by T at position 17, L by N at position 20, L by Q at position 20, L by R at position 20, L by S at position 20, L by T at position 20, L by D at position 20, L by E at position 20, L by K at position 20, W by D at position 22, W by E at position 22, W by K at position 22, W by R at position 22, Q by D at position 23, Q by E at position 23, Q by K at position 23, Q by R at position 23, L by D at position 24, L by E at position 24, L by K at position 24, L by R at position 24, W by D at position 79, W by E at position 79, W by K at position 79, W by R at position 79, N by D at position 80, N by E at position 80, N by K at position 80, N by R at position 80, T by D at position 82, T by E at position 82, T by K at position 82, T by R at position 82, I by D at position 83, I by E at position 83, I by K at position 83, I by R at position 83, I by N at position 83, I by Q at position 83, I by S at position 83, I by T at position 83, N by D at position 86, N by E at position 86, N by K at position 86, N by R at position 86, N by Q at position 86, N by S at position 86, N by T at position 86, L by D at position 87, L by E at position 87, L by K at position 87, L by R at position 87, L by N at position 87, L by Q at position 87, L by S at position 87, L by T at position 87, A by D at position 89, A by E at position 89, A by K at position 89, A by R at position 89, N by D at position 90, N by E at position 90, N by K at position 90, N by Q at position 90, N by R at position 90, N by S at position 90, N by T at position 90, V by D at position 91, V by E at position 91, V by K at position 91, V by N at position 91, V by Q at position 91, V by R at

position 91, V by S at position 91, V by T at position 91, Q by D at position 94, Q by E at position 94, Q by Q at position 94, Q by N at position 94, Q by R at position 94, Q by S at position 94, Q by T at position 94, I by D at position 95, I by E at position 95, I by K at position 95, I by N at position 95, I by Q at position 95, I by R at position 95, I by S at position 95, I by T at position 95, H by D at position 97, H by E at position 97, H by K at position 97, H by N at position 97, H by Q at position 97, H by R at position 97, H by S at position 97, H by T at position 97, L by D at position 98, L by E at position 98, L by K at position 98, L by N at position 98, L by Q at position 98, L by R at position 98, L by S at position 98, L by T at position 98, V by D at position 101, V by E at position 101, V by K at position 101, V by N at position 101, V by Q at position 101, V by R at position 101, V by S at position 101, V by T at position 101, M by C at position 1, L by C at position 6, Q by C at position 10, S by C at position 13, Q by C at position 16, L by C at position 17, V by C at position 101, L by C at position 98, H by C at position 97, Q by C at position 94, V by C at position 91, or N by C at position 90, wherein residue 1 corresponds to residue 1 of the mature IFN- $\beta$  cytokine set forth in SEQ ID NO:196; and further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

### 3-D structural homologs

[00489] In other embodiments, the hyperglycosylated, protease-resistant interferon variant is a modified IFN- $\beta$  cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:196 (as set forth in Figure 3) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\beta$ . In some of these embodiments, the modified IFN- $\beta$  is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 196 (as set forth in Figure 3), corresponding to any of amino acid positions: 39, 42, 45, 47, 52, 67, 71, 73, 81, 107, 108, 109, 110, 111, 113, 116, 120, 123, 124, 128, 130, 134, 136, 137, 163 and 165, where the mutations include insertions, deletions and replacements of the native amino acid residue(s); where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00490] In other embodiments, the hyperglycosylated, protease-resistant interferon variant is a modified IFN- $\beta$  cytokine comprising one or more amino acid replacements, where the replacements are selected from amino acid substitutions in SEQ ID NO:196 (as set forth in Figure 3) corresponding to: D by Q at position 39, D by H at position 39, D by G at position 39, E by Q at position 42, E by H at position 42, K by Q at position 45, K by T at position 45, K by S at position 45, K by H at position 45, L by V at position 47, L by I at position 47, L by T at position 47, L by Q at position 47, L by H at position 47, L by A at position 47, K by Q at position 52, K by T at position 52, K by S at position 52, K by H at position 52, F by I at position 67, F by V at position 67, R by H at position 71, R by Q at position 71, D by H at position 73, D by G at position 73, D by Q at position 73, E by Q at position 81, E by H at position 81, E by Q at position 107, E by H at position 107, K by Q at position 108, K by T at position 108, K by S at position 108, K by H at position 108, E by Q at position 109, E by H at position 109, D by Q at position 110, D by H at position 110, D by G at position 110, F by I at position 111, F by V at position 111, R by H at position 113, R by Q at position 113, L by V at position 116, L by I at position 116, L by T at position 116, L by Q at position 116, L by H at position 116, L by A at position 116, L by V at position 120, L by I at position 120, L by T at position 120, L by Q at position 120, L by H at position 120, L by A at position 120, K by Q at position 123, K by T at position 123, K by S at position 123, K by H at position 123, R by H at position 124,, R by Q at position 124, R by H at position 128, R by Q at position 128, L by V at position 130, L by I at position 130, L by T at position 130, L by Q at position 130, L by H at position 130, L by A at position 130, K by Q at position 134, K by T at position 134, K by S at position 134, K by H at position 134, K by Q at position 136, K by T at position 136, K by S at position 136,, K by H at position 136, E by Q at position 137, E by H at position 137, Y by H at position 163, Y by I at position 163, R by H at position 165, or R by Q at position 165, wherein the first amino acid listed is substituted by the second at the position indicated; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00491] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\beta$  variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\beta$  variants has increased biological activity compared to the unmodified (parent) cytokine, after

incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00492] In other embodiments, the hyperglycosylated, protease-resistant interferon variant is a modified IFN- $\beta$ 1 cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:197 (as set forth in Figure 22) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\beta$ 1. In some of these embodiments, the modified IFN- $\beta$ 1 is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 197 (as set forth in Figure 22), corresponding to any of amino acid positions: 39, 42, 45, 47, 52, 67, 71, 73, 81, 107, 108, 109, 110, 111, 113, 116, 120, 123, 124, 128, 130, 134, 136, 137, 163 and 165, where the mutations include insertions, deletions and replacements of the native amino acid residue(s); where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00493] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\beta$ 1 variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\beta$ 1 variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00494] In other embodiments, the protease-resistant interferon variant is a modified IFN- $\beta$ 2a cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:198 (as set forth in Figure 23) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\beta$ 2a. In some of these embodiments, the modified IFN- $\beta$ 2a is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 198 (as set forth in Figure 23),



corresponding to any of amino acid positions: 39, 42, 45, 47, 52, 67, 71, 73, 81, 107, 108, 109, 110, 111, 113, 116, 120, 123, 124, 128, 130, 134, 136, 137, 163 and 165, where the mutations include insertions, deletions and replacements of the native amino acid residue(s); where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00495] In some embodiments, any of the above-described hyperglycosylated, protease-resistant polypeptide IFN- $\beta$ 2a variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\beta$ 2a variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00496] In another aspect, the present invention provides a cytokine structural homolog of any of the above-described protease-resistant IFN- $\beta$  variants, where the homolog comprises one or more amino acid replacements at positions corresponding to the 3-dimensional-structurally-similar modified positions within the 3-dimensional structure of the modified IFN- $\beta$ . In many embodiments, the homolog has increased resistance to proteolysis compared to its unmodified cytokine counterpart, wherein the resistance to proteolysis is measured by mixture with a protease in vitro, incubation with blood, or incubation with serum. In many embodiments, the cytokine is an IFN- $\beta$  cytokine.

[00497] In another aspect, the present invention provides a modified IFN- $\beta$  cytokine (e.g., a hyperglycosylated, protease-resistant IFN- $\beta$  variant), comprising one or more amino acid replacements at one or more target positions in SEQ ID NO. 196 (the amino acid sequence set forth in Figure 3) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of any of the above-described IFN- $\beta$  modified cytokines, where the replacements lead to greater resistance to proteases, as assessed by incubation with a protease or a with a blood lysate or by incubation with serum, compared to the unmodified IFN- $\beta$ .

[00498] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\beta$  variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity to either inhibit viral replication or to stimulate cell proliferation in appropriate cells, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00499] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\beta$  variants has increased biological activity compared to the unmodified (parent) cytokine, where the activity is assessed by the capacity to either inhibit viral replication in appropriate cells, or to inhibit cell proliferation in appropriate cells, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

[00500] In some embodiments, a hyperglycosylated, protease-resistant IFN- $\beta$  variant (a “modified IFN- $\beta$  cytokine”) is selected from the group of proteins comprising one or more single amino acid replacements in SEQ ID NO:196, as set forth in Figure 3, corresponding to the replacement of: M by V at position 1, M by I at position 1, M by T at position 1, M by Q at position 1, M by A at position 1, L by V at position 5, L by I at position 5, L by T at position 5, L by Q at position 5, L by H at position 5, L by A at position 5, F by I at position 8, F by V at position 8, L by V at position 9, L by I at position 9, L by T at position 9, L by Q at position 9, L by H at position 9, L by A at position 9, R by H at position 11, R by Q at position 11, F by I at position 15, F by V at position 15, K by Q at position 19, K by T at position 19, K by S at position 19, K by H at position 19, W by S at position 22, W by H at position 22, N by H at position 25, N by S at position 25, N by Q at position 25, R by H position 27, R by Q position 27, L by V at position 28, L by I at position 28, L by T at position 28, L by Q at position 28, L by H at position 28, L by A at position 28, E by Q at position 29, E by H at position 29, Y by H at position 30, Y by I at position 30, L by V at position 32, L by I at position 32, L by T at position 32, L by Q at position 32, L by H at position 32, L by A at position 32, K by Q at position 33, K by T at position 33, K by S at position 33, K by H at position 33, R by H at position 35, R by Q at position 35, M by V at position 36, M by I at position 36, M by T at position 36, M by Q at position 36, M by A at position 36, D by Q at position 39, D by H at position 39, D by G at position 39, E by Q at position 42, E by H at position 42, K by Q at position 45, K by T at position 45, K by S at position 45, K by H at position 45, L by V at position 47, L by I at position 47, L by T at position 47, L by, Q at position 47, L by H at position 47, L by A at position 47, K by Q at position 52, K by T at position 52, K by S at position 52, K by H at position 52, F by I at position 67, F by V at position 67, R by H at position 71, R by Q at position 71, D by Q at position 73, D by H at position 73, D by G at position 73, E by Q at position 81, E by H at position 81, E by Q at position 85, E by H at position 85, Y by H at position 92, Y by I at position 92, K by Q at position 99, K by T at position 99, K by S at position 99, K by H at position 99, E by Q at position 103, E by H at position 103, E by Q at position 104, E by H at position 104, K by Q at position 105, K by T at position 105, K by S at position 105, K by H at position 105, E by Q at position 107, E by H at

position 107, K by Q at position 108, K by T at position 108, K by S at position 108, K by H at position 108, E by Q at position 109, E by H at position 109, D by Q at position 110, D by H at position 110, D by G at position 110, F by I at position 111, F by V at position 111, R by H at position 113, R by Q at position 113, L by V at position 116, L by I at position 116, L by T at position 116, L by Q at position 116, L by H at position 116, L by A at position 116, L by V at position 120, L by I at position 120, L by T at position 120, L by Q at position 120, L by H at position 120, L by A at position 120, K by Q at position 123, K by T at position 123, K by S at position 123, K by H at position 123, R by H at position 124, R by Q at position 124, R by H at position 128, R by Q at position 128, L by V at position 130, L by I at position 130, L by T at position 130, L by Q at position 130, L by H at position 130, L by A at position 130, K by Q at position 134, K by T at position 134, K by S at position 134, K by H at position 134, K by Q at position 136, K by T at position 136, K by S at position 136, K by H at position 136, E by Q at position 137, E by H at position 137, Y by H at position 138, Y by I at position 138, R by H at position 152, R by Q at position 152, Y by H at position 155, Y by I at position 155, R by H at position 159, R by Q at position 159, Y by H at position 163, Y by I at position 163, R by H at position 165, R by Q at position 165, M by D at position 1, M by E at position 1, M by K at position 1, M by N at position 1, M by R at position 1, M by S at position 1, L by D at position 5, L by E at position 5, L by K at position 5, L by N at position 5, L by R at position 5, L by S at position 5, L by D at position 6, L by E at position 6, L by K at position 6, L by N at position 6, L by R at position 6, L by S at position 6, L by Q at position 6, L by T at position 6, F by E at position 8, F by K at position 8, F by R at position 8, F by D at position 8, L by D at position 9, L by E at position 9, L by K at position 9, L by N at position 9, L by R at position 9, L by S at position 9, Q by D at position 10, Q by E at position 10, Q by K at position 10, Q by N at position 10, Q by R at position 10, Q by S at position 10, Q by T at position 10, S by D at position 12, S by E at position 12, S by K at position 12, S by R at position 12, S by D at position 13, S by E at position 13, S by K at position 13, S by R at position 13, S by N at position 13, S by Q at position 13, S by T at position 13, N by D at position 14, N by E at position 14, N by K at position 14, N by Q at position 14, N by R at position 14, N by S at position 14, N by T at position 14, F by D at position 15, F by E at position 15, F by K at position 15, F by R at position 15, Q by D at position 16, Q by E at position 16, Q by K at position 16, Q by N at position 16, Q by R at position 16, Q by S at position 16, Q by T at position 16, C by D at position 17, C by E at position 17, C by K at position 17, C by N at position 17, C by Q at position 17, C by R at position 17, C by S at position 17, C by T at position 17, L by N at position 20, L by Q at position 20, L by R at position 20, L by S at

position 20, L by T at position 20, L by D at position 20, L by E at position 20, L by K at position 20, W by D at position 22, W by E at position 22, W by K at position 22, W by R at position 22, Q by D at position 23, Q by E at position 23, Q by K at position 23, Q by R at position 23, L by D at position 24, L by E at position 24, L by K at position 24, L by R at position 24, W by D at position 79, W by E at position 79, W by K at position 79, W by R at position 79, N by D at position 80, N by E at position 80, N by K at position 80, N by R at position 80, T by D at position 82, T by E at position 82, T by K at position 82, T by R at position 82, I by D at position 83, I by E at position 83, I by K at position 83, I by R at position 83, I by N at position 83, I by Q at position 83, I by S at position 83, I by T at position 83, N by D at position 86, N by E at position 86, N by K at position 86, N by R at position 86, N by Q at position 86, N by S at position 86, N by T at position 86, L by D at position 87, L by E at position 87, L by K at position 87, L by R at position 87, L by N at position 87, L by Q at position 87, L by S at position 87, L by T at position 87, A by D at position 89, A by E at position 89, A by K at position 89, A by R at position 89, N by D at position 90, N by E at position 90, N by K at position 90, N by Q at position 90, N by R at position 90, N by S at position 90, N by T at position 90, V by D at position 91, V by E at position 91, V by K at position 91, V by N at position 91, V by Q at position 91, V by R at position 91, V by S at position 91, V by T at position 91, Q by D at position 94, Q by E at position 94, Q by Q at position 94, Q by N at position 94, Q by R at position 94, Q by S at position 94, Q by T at position 94, I by D at position 95, I by E at position 95, I by K at position 95, I by N at position 95, I by Q at position 95, I by R at position 95, I by S at position 95, I by T at position 95, H by D at position 97, H by E at position 97, H by K at position 97, H by N at position 97, H by Q at position 97, H by R at position 97, H by S at position 97, H by T at position 97, L by D at position 98, L by E at position 98, L by K at position 98, L by N at position 98, L by Q at position 98, L by R at position 98, L by S at position 98, L by T at position 98, V by D at position 101, V by E at position 101, V by K at position 101, V by N at position 101, V by Q at position 101, V by R at position 101, V by S at position 101, V by T at position 101, M by C at position 1, L by C at position 6, Q by C at position 10, S by C at position 13, Q by C at position 16, L by C at position 17, V by C at position 101, L by C at position 98, H by C at position 97, Q by C at position 94, V by C at position 91, or N by C at position 90, or any combination of such replacements, wherein residue 1 corresponds to residue 1 of the mature IFN- $\beta$  cytokine set forth in SEQ ID NO:196 (as set forth in Figure 3); where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the

parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00501] In other embodiments, a hyperglycosylated, protease-resistant IFN- $\beta$  variant (a “modified IFN- $\beta$  cytokine”) is selected from the group of proteins comprising one or more single amino acid replacements in SEQ ID NO:196, as set forth in Figure 3, corresponding to the replacement of: D by Q at position 39, D by H at position 39, D by G at position 39, E by Q at position 42, E by H at position 42, K by Q at position 45, K by T at position 45, K by S at position 45, K by H at position 45, L by V at position 47, L by I at position 47, L by T at position 47, L by Q at position 47, L by H at position 47, L by A at position 47, K by Q at position 52, K by T at position 52, K by S at position 52, K by H at position 52, F by I at position 67, F by V at position 67, R by H at position 71, R by Q at position 71, D by H at position 73, D by G at position 73, D by Q at position 73, E by Q at position 81, E by H at position 81, E by Q at position 107, E by H at position 107, K by Q at position 108, K by T at position 108, K by S at position 108, K by H at position 108, E by Q at position 109, E by H at position 109, D by Q at position 110, D by H at position 110, D by G at position 110, F by I at position 111, F by V at position 111, R by H at position 113, R by Q at position 113, L by V at position 116, L by I at position 116, L by T at position 116, L by Q at position 116, L by H at position 116, L by A at position 116, L by V at position 120, L by I at position 120, L by T at position 120, L by Q at position 120, L by H at position 120, L by A at position 120, K by Q at position 123, K by T at position 123, K by S at position 123, K by H at position 123, R by H at position 124,, R by Q at position 124, R by H at position 128, R by Q at position 128, L by V at position 130, L by I at position 130, L by T at position 130, L by Q at position 130, L by H at position 130, L by A at position 130, K by Q at position 134, K by T at position 134, K by S at position 134, K by H at position 134, K by Q at position 136, K by T at position 136, K by S at position 136, K by H at position 136, E by Q at position 137, E by H at position 137, Y by H at position 163, Y by I at position 163, R by H at position 165, or R by Q at position 165, or any combination of such replacements, wherein the first amino acid listed is substituted by the second at the position indicated; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00502] In some embodiments, a hyperglycosylated, protease-resistant IFN- $\beta$  variant (a “modified IFN- $\beta$  cytokine”) is selected from the group of proteins comprising one or more single amino acid replacements in SEQ ID NO:196, as set forth in Figure 3, corresponding to the replacement of: M by V at position 1, M by I at position 1, M by T at position 1, M by Q at

position 1, M by A at position 1, L by V at position 5, L by I at position 5, L by T at position 5, L by Q at position 5, L by H at position 5, L by A at position 5, F by I at position 8, F by V at position 8, L by V at position 9, L by I at position 9, L by T at position 9, L by Q at position 9, L by H at position 9, L by A at position 9, R by H at position 11, R by Q at position 11, F by I at position 15, F by V at position 15, K by Q at position 19, K by T at position 19, K by S at position 19, K by H at position 19, W by S at position 22, W by H at position 22, N by H at position 25, N by S at position 25, N by Q at position 25, R by H position 27, R by Q position 27, L by V at position 28, L by I at position 28, L by T at position 28, L by Q at position 28, L by H at position 28, L by A at position 28, E by Q at position 29, E by H at position 29, Y by H at position 30, Y by I at position 30, L by V at position 32, L by I at position 32, L by T at position 32, L by Q at position 32, L by H at position 32, L by A at position 32, K by Q at position 33, K by T at position 33, K by S at position 33, K by H at position 33, R by H at position 35, R by Q at position 35, M by V at position 36, M by I at position 36, M by T at position 36, M by Q at position 36, M by A at position 36, D by Q at position 39, D by H at position 39, D by G at position 39, E by Q at position 42, E by H at position 42, K by Q at position 45, K by T at position 45, K by S at position 45, K by H at position 45, L by V at position 47, L by I at position 47, L by T at position 47, L by, Q at position 47, L by H at position 47, L by A at position 47, K by Q at position 52, K by T at position 52, K by S at position 52, K by H at position 52, F by I at position 67, F by V at position 67, R by H at position 71, R by Q at position 71, D by Q at position 73, D by H at position 73, D by G at position 73, E by Q at position 81, E by H at position 81, E by Q at position 85, E by H at position 85, Y by H at position 92, Y by I at position 92, K by 0 at position 99, K by T at position 99, K by S at position 99, K by H at position 99, E by Q at position 103, E by H at position 103, E by Q at position 104, E by H at position 104, K by Q at position 105, K by T at position 105, K by S at position 105, K by H at position 105, E by Q at position 107, E by H at position 107, K by Q at position 108, K by T at position 108, K by S at position 108, K by H at position 108, E by Q at position 109, E by H at position 109, D by Q at position 110, D by H at position 110, D by G at position 110, F by I at position 111, F by V at position 111, R by H at position 113, R by Q at position 113, L by V at position 116, L by I at position 116, L by T at position 116, L by Q at position 116, L by H at position 116, L by A at position 116, L by V at position 120, L by I at position 120, L by T at position 120, L by Q at position 120, L by H at position 120, L by A at position 120, K by Q at position 123, K by T at position 123, K by S at position 123, K by H at position 123, R by H at position 124, R by Q at position 124, R by H at position 128, R by Q at position 128, L by V at position 130, L by I at position 130, L by T at

position 130, L by Q at position 130, L by H at position 130, L by A at position 130, K by Q at position 134, K by T at position 134, K by S at position 134, K by H at position 134, K by Q at position 136, K by T at position 136, K by S at position 136, K by H at position 136, E by Q at position 137, E by H at position 137, Y by H at position 138, Y by I at position 138, R by H at position 152, R by Q at position 152, Y by H at position 155, Y by I at position 155, R by H at position 159, R by Q at position 159, Y by H at position 163, Y by I at position 163, R by H at position 165, R by Q at position 165, M by D at position 1, M by E at position 1, M by K at position 1, M by N at position 1, M by R at position 1, M by S at position 1, L by D at position 5, L by E at position 5, L by K at position 5, L by N at position 5, L by R at position 5, L by S at position 5, L by D at position 6, L by E at position 6, L by K at position 6, L by N at position 6, L by R at position 6, L by S at position 6, L by Q at position 6, L by T at position 6, F by E at position 8, F by K at position 8, F by R at position 8, F by D at position 8, L by D at position 9, L by E at position 9, L by K at position 9, L by N at position 9, L by R at position 9, L by S at position 9, Q by D at position 10, Q by E at position 10, Q by K at position 10, Q by N at position 10, Q by R at position 10, Q by S at position 10, Q by T at position 10, S by D at position 12, S by E at position 12, S by K at position 12, S by R at position 12, S by D at position 13, S by E at position 13, S by K at position 13, S by R at position 13, S by N at position 13, S by Q at position 13, S by T at position 13, N by D at position 14, N by E at position 14, N by K at position 14, N by Q at position 14, N by R at position 14, N by S at position 14, N by T at position 14, F by D at position 15, F by E at position 15, F by K at position 15, F by R at position 15, Q by D at position 16, Q by E at position 16, Q by K at position 16, Q by N at position 16, Q by R at position 16, Q by S at position 16, Q by T at position 16, C by D at position 17, C by E at position 17, C by K at position 17, C by N at position 17, C by Q at position 17, C by R at position 17, C by S at position 17, C by T at position 17, L by N at position 20, L by Q at position 20, L by R at position 20, L by S at position 20, L by T at position 20, L by D at position 20, L by E at position 20, L by K at position 20, W by D at position 22, W by E at position 22, W by K at position 22, W by R at position 22, Q by D at position 23, Q by E at position 23, Q by K at position 23, Q by R at position 23, L by D at position 24, L by E at position 24, L by K at position 24, L by R at position 24, W by D at position 79, W by E at position 79, W by K at position 79, W by R at position 79, N by D at position 80, N by E at position 80, N by K at position 80, N by R at position 80, T by D at position 82, T by E at position 82, T by K at position 82, T by R at position 82, I by D at position 83, I by E at position 83, I by K at position 83, I by R at position 83, I by N at position 83, I by Q at position 83, I by S at position 83, I by T at position 83, N by

D at position 86, N by E at position 86, N by K at position 86, N by R at position 86, N by Q at position 86, N by S at position 86, N by T at position 86, L by D at position 87, L by E at position 87, L by K at position 87, L by R at position 87, L by N at position 87, L by Q at position 87, L by S at position 87, L by T at position 87, A by D at position 89, A by E at position 89, A by K at position 89, A by R at position 89, N by D at position 90, N by E at position 90, N by K at position 90, N by Q at position 90, N by R at position 90, N by S at position 90, N by T at position 90, V by D at position 91, V by E at position 91, V by K at position 91, V by N at position 91, V by Q at position 91, V by R at position 91, V by S at position 91, V by T at position 91, Q by D at position 94, Q by E at position 94, Q by Q at position 94, Q by N at position 94, Q by R at position 94, Q by S at position 94, Q by T at position 94, I by D at position 95, I by E at position 95, I by K at position 95, I by N at position 95, I by Q at position 95, I by R at position 95, I by S at position 95, I by T at position 95, H by D at position 97, H by E at position 97, H by K at position 97, H by N at position 97, H by Q at position 97, H by R at position 97, H by S at position 97, H by T at position 97, L by D at position 98, L by E at position 98, L by K at position 98, L by N at position 98, L by Q at position 98, L by R at position 98, L by S at position 98, L by T at position 98, V by D at position 101, V by E at position 101, V by K at position 101, V by N at position 101, V by Q at position 101, V by R at position 101, V by S at position 101, V by T at position 101, M by C at position 1, L by C at position 6, Q by C at position 10, S by C at position 13, Q by C at position 16, L by C at position 17, V by C at position 101, L by C at position 98, H by C at position 97, Q by C at position 94, V by C at position 91, N by C at position 90, D by Q at position 39, D by H at position 39, D by G at position 39, E by Q at position 42, E by H at position 42, K by Q at position 45, K by T at position 45, K by S at position 45, K by H at position 45, L by V at position 47, L by I at position 47, L by T at position 47, L by Q at position 47, L by H at position 47, L by A at position 47, K by Q at position 52, K by T at position 52, K by S at position 52, K by H at position 52, F by I at position 67, F by V at position 67, R by H at position 71, R by Q at position 71, D by H at position 73, D by G at position 73, D by Q at position 73, E by Q at position 81, E by H at position 81, E by Q at position 107, E by H at position 107, K by Q at position 108, K by T at position 108, K by S at position 108, K by H at position 108, E by Q at position 109, E by H at position 109, D by Q at position 110, D by H at position 110, D by G at position 110, F by I at position 111, F by V at position 111, R by H at position 113, R by Q at position 113, L by V at position 116, L by I at position 116, L by T at position 116, L by Q at position 116, L by H at position 116, L by A at position 116, L by V at position 120, L by I at position 120, L by T at position 120, L by Q at



position 120, L by H at position 120, L by A at position 120, K by Q at position 123, K by T at position 123, K by S at position 123, K by H at position 123, R by H at position 124, R by Q at position 124, R by H at position 128, R by Q at position 128, L by V at position 130, L by I at position 130, L by T at position 130, L by Q at position 130, L by H at position 130, L by A at position 130, K by Q at position 134, K by T at position 134, K by S at position 134, K by H at position 134, K by Q at position 136, K by T at position 136, K by S at position 136, K by H at position 136, E by Q at position 137, E by H at position 137, Y by H at position 163, Y by I at position 163, R by H at position 165, or R by Q at position 165, or any combination of such replacements, wherein the first amino acid listed is substituted by the second at the position indicated; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00503] In particular embodiments, a hyperglycosylated, protease-resistant IFN- $\beta$  variant (a “modified IFN- $\beta$  cytokine”) is selected from the group consisting of a modified IFN- $\beta$  comprising an amino acid sequence as depicted in any of SEQ ID Nos.234-289, and 989-1302; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

[00504] In particular embodiments, a hyperglycosylated, protease-resistant IFN- $\beta$  variant (a “modified IFN- $\beta$  cytokine”) comprises one or more of the amino acid replacements set forth in Table 2 (IFN- $\beta$ ); where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

Table 2 (IFN- $\beta$ )

1.	D39Q	16.	D73Q	31.	F111I	46.	L130I
2.	D39N	17.	D73N	32.	F111V	47.	K134Q
3.	E42Q	18.	E81Q	33.	R113H	48.	K134N
4.	E42N	19.	E81N	34.	R113Q	49.	K136Q
5.	E42H	20.	E81H	35.	L116V	50.	K136N
6.	K45Q	21.	E107Q	36.	L116I	51.	E137Q
7.	K45N	22.	E107N	37.	L120V	52.	E137N
8.	L47V	23.	E107H	38.	L120I	53.	E137H
9.	L47I	24.	K108Q	39.	K123Q	54.	Y163H
10.	K52Q	25.	K108N	40.	K123N	55.	Y163I
11.	K52N	26.	E109Q	41.	R124H	56.	R165H
12.	F67I	27.	E109N	42.	R124Q	57.	R165Q
13.	F67V	28.	E109H	43.	R128H		
14.	R71H	29.	D110Q	44.	R128Q		
15.	R71Q	30.	D110N	45.	L130V		

[00505] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1a, and the variant is an [S99N]IFN- $\beta$ 1a glycopeptide, where the [S99N]IFN- $\beta$ 1a glycopeptide is a variant of IFN- $\beta$ 1a having (a) an asparagine residue substituted for the native serine residue at amino acid position 99 in the amino acid sequence of IFN- $\beta$ 1a (where the S99 amino acid position is as set forth in Figure 24; and corresponds to S74 in the IFN- $\beta$  amino acid sequence set forth in Figure 3); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.

[00506] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1a, and the variant is an [S99N, E134N]IFN- $\beta$ 1a glycopeptide, where the [S99N, E134N]IFN- $\beta$ 1a glycopeptide is a variant of IFN- $\beta$ 1a having (a) an asparagine residue substituted for each of the native serine and glutamic acid residues at amino acid positions 99 and 134, respectively, in the amino acid sequence of IFN- $\beta$ 1a (where the S99 and E134 amino acid positions are as set forth in Figure 24; and correspond to S74 and E109, respectively, in the IFN- $\beta$  amino acid sequence set forth in Figure 3); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

[00507] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1a, and the variant is an [S99N, E134N, F136T]IFN- $\beta$ 1a glycopeptide, where the [S99N, E134N, F136T]IFN- $\beta$ 1a glycopeptide is a variant of IFN- $\beta$ 1a having (a) asparagine, asparagine and threonine residues substituted for the native serine, glutamic acid and phenylalanine residues at amino acid positions 99, 134 and 136, respectively, in the amino acid sequence of IFN- $\beta$ 1a (where the

S99, E134, and F136 amino acid positions are as set forth in Figure 24; and correspond to S74, E109, and F111, respectively, in the IFN- $\beta$  amino acid sequence set forth in Figure 3); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.

[00508] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1a, and the variant is an [E134N]IFN- $\beta$ 1a glycopeptide, where the [E134N]IFN- $\beta$ 1a glycopeptide is a variant of IFN- $\beta$ 1a having (a) an asparagine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of IFN- $\beta$ 1a (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.

[00509] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1a, and the variant is an [E134N, F136T]IFN- $\beta$ 1a glycopeptide, where the [E134N, F136T]IFN- $\beta$ 1a glycopeptide is a variant of IFN- $\beta$ 1a having (a) asparagine and threonine residues substituted for the native glutamic acid and phenylalanine residues at amino acid positions 134 and 136, respectively, in the amino acid sequence of IFN- $\beta$ 1a (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.

[00510] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1a, and the variant is an [E134T]IFN- $\beta$ 1a glycopeptide, where the [E134T]IFN- $\beta$ 1a glycopeptide is a variant of IFN- $\beta$ 1a having (a) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of IFN- $\beta$ 1a (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of said threonine residue.

[00511] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1a, and the variant is an [S99N, E134T]IFN- $\beta$ 1a glycopeptide, where the [S99N, E134T]IFN- $\beta$ 1a glycopeptide is a variant of IFN- $\beta$ 1a having (a) asparagine and threonine residues substituted for the native serine and glutamic acid residues at amino acid positions 99 and 134, respectively, in the amino acid sequence of IFN- $\beta$ 1a (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues.

- [00512] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1b, and the variant is an [S99N]IFN- $\beta$ 1b glycopeptide, where the [S99N]IFN- $\beta$ 1b glycopeptide is a variant of IFN- $\beta$ 1b having (a) an asparagine residue substituted for the native serine residue at amino acid position 99 in the amino acid sequence of IFN- $\beta$ 1b (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.
- [00513] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1b, and the variant is an [S99N, E134N]IFN- $\beta$ 1b glycopeptide, where the [S99N, E134N]IFN- $\beta$ 1b glycopeptide is a variant of IFN- $\beta$ 1b having (a) an asparagine residue substituted for the native serine residue and glutamic acid residue at amino acid positions 99 and 134, respectively, in the amino acid sequence of IFN- $\beta$ 1b (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.
- [00514] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1b, and the variant is an [S99N, E134N, F136T]IFN- $\beta$ 1b glycopeptide, where the [S99N, E134N, F136T]IFN- $\beta$ 1b glycopeptide is a variant of IFN- $\beta$ 1b having (a) asparagine, asparagine and threonine residues substituted for the native serine, glutamic acid and phenylalanine residues at amino acid positions 99, 134 and 136, respectively, in the amino acid sequence of IFN- $\beta$ 1b (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine residues.
- [00515] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1b, and the variant is an [E134N]IFN- $\beta$ 1b glycopeptide, where the [E134N]IFN- $\beta$ 1b glycopeptide is a variant of IFN- $\beta$ 1b having (a) an asparagine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of IFN- $\beta$ 1b (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.
- [00516] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1b, and the variant is an [E134N, F136T]IFN- $\beta$ 1b glycopeptide, where the [E134N, F136T]IFN- $\beta$ 1b glycopeptide is a variant of IFN- $\beta$ 1b having (a) asparagine and threonine residues substituted for the native glutamic acid and phenylalanine residues at amino acid positions 134 and 136, respectively, in

the amino acid sequence of IFN- $\beta$ 1b (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of said asparagine residue.

[00517] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1b, and the variant is an [E134T]IFN- $\beta$ 1b glycopeptide, where the [E134T]IFN- $\beta$ 1b glycopeptide is a variant of IFN- $\beta$ 1b having (a) a threonine residue substituted for the native glutamic acid residue at amino acid position 134 in the amino acid sequence of IFN- $\beta$ 1b (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of said threonine residue.

[00518] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  variants is a variant of IFN- $\beta$ 1b, and the variant is an [S99N, E134T]IFN- $\beta$ 1b glycopeptide, where the [S99N, E134T]IFN- $\beta$ 1b glycopeptide is a variant of IFN- $\beta$ 1b having (a) asparagine and threonine residues substituted for the native serine and glutamic acid residues at amino acid positions 99 and 134, respectively, in the amino acid sequence of IFN- $\beta$ 1b (where the amino acid positions are as set forth in Figure 24); and (b) a carbohydrate moiety covalently attached to the R-group of each of said asparagine and threonine residues.

#### **IFN- $\gamma$ polypeptide variants**

[00519] In other embodiments, the hyperglycosylated, protease-resistant interferon variant is a modified IFN- $\gamma$  cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:199 (as set forth in Figure 4) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified IFN- $\gamma$ . In some of these embodiments, the modified IFN- $\gamma$  is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 199 (as set forth in Figure 4), corresponding to any of amino acid positions: 33, 37, 40, 41, 42, 58, 61, 64, 65 and 66, where the mutations include insertions, deletions and replacements of the native amino acid residue(s). In particular embodiments, the replacements are selected from among amino acid substitutions in SEQ ID NO:199 set forth in Table 3, below, where the first amino acid listed is substituted by the second amino acid at the position indicated; and where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent

polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

**Table 3**

1.	L33V	12.	E42H
2.	L33I	13.	K58Q
3.	K37Q	14.	K58N
4.	K37N	15.	K61Q
5.	K40Q	16.	K61N
6.	K40N	17.	K64Q
7.	E41Q	18.	K64N
8.	E41N	19.	D65Q
9.	E41H	20.	D65N
10.	E42Q	21.	D66Q
11.	E42N		

[00520] In other embodiments, the modified IFN- $\gamma$  comprises an amino acid sequence corresponding to any of SEQ ID NOS: 290-311, and further comprises one or more glycosylation sites not found in the parent polypeptide.

[00521] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\gamma$  variants is an [S99T]IFN-gamma glycopeptide, where the [S99T]IFN-gamma glycopeptide is a variant of the mature, native IFN-gamma having (a) a threonine residue substituted for the native serine residue at amino acid position 99 in the amino acid sequence of IFN-gamma depicted in Figure 31 (corresponding to S102 of the IFN- $\gamma$  amino acid sequence set forth in Figure 4); and (b) a carbohydrate moiety covalently attached to the R-group of the asparagine residue at amino acid position 97 in the amino acid sequence of (a); and comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide.

[00522] Since the glycosylation site formed by N97, Y98, T99 in the [S99T]IFN-gamma variant is different than the glycosylation site formed by N97, Y98, S99 in native IFN-gamma, the N97, Y98, T99 glycosylation site qualifies as a non-native glycosylation site not found in the parent polypeptide. In addition, as described in WO 02/081507, the S99T substitution in the amino acid sequence of native IFN-gamma provides for greater efficiency of glycosylation at the N97, Y98, T99 glycosylation site in the [S99T]IFN-gamma variant compared to the efficiency of glycosylation at the N97, Y98, S99 glycosylation site in native IFN-gamma. Thus, [S99T]IFN-gamma qualifies as a hyperglycosylated polypeptide variant of the parent IFN-gamma polypeptide (where the N97, Y98, and S99 amino acid positions in the IFN- $\gamma$  amino acid sequence set forth in Figure 31 correspond to N100, Y101, and S102 in the IFN- $\gamma$  amino acid sequence set forth in Figure 4).

[00523] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\gamma$  variants is an [E38N]IFN-gamma glycopeptide, where the [E38N]IFN-gamma glycopeptide is a variant of the mature, native IFN-gamma having (a) an asparagine residue substituted for the native glutamic acid residue at amino acid position 38 in the amino acid sequence of IFN-gamma depicted in Figure 31 (where amino acid E38 in the IFN- $\gamma$  amino acid sequence set forth in Figure 31 corresponds to E41 of the IFN- $\gamma$  amino acid sequence set forth in Figure 4); and (b) a carbohydrate moiety covalently attached to the R-group of the asparagine residue at amino acid position 38 in the amino acid sequence of (a); and comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide.

[00524] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\gamma$  variants is an [E38N, S99T]IFN-gamma glycopeptide, where the [E38N, S99T]IFN-gamma glycopeptide is a variant of the mature, native IFN-gamma having (a) asparagine and threonine residues substituted for the native glutamic acid and serine residues at amino acid positions 38 and 99 in the amino acid sequence of IFN-gamma depicted in Figure 31 (where amino acids E38 and S99 in the IFN- $\gamma$  amino acid sequence set forth in Figure 31 correspond to E41 and S102, respectively, of the IFN- $\gamma$  amino acid sequence set forth in Figure 4); and (b) a carbohydrate moiety covalently attached to the R-group of the asparagine residue at each of amino acid positions 38 and 97 in the amino acid sequence of (a); and comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide.

[00525] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\gamma$  variants is an [E38N, S40T]IFN-gamma glycopeptide, where the [E38N, S40T]IFN-gamma glycopeptide is a variant of the mature, native IFN-gamma having (a) asparagine and threonine residues substituted for the native glutamic acid and serine residues at amino acid positions 38 and 40 in the amino acid sequence of IFN-gamma depicted in Figure 31 (where amino acids E38 and S40 in the IFN- $\gamma$  amino acid sequence set forth in Figure 31 correspond to E41 and S43, respectively, of the IFN- $\gamma$  amino acid sequence set forth in Figure 4); and (b) a carbohydrate moiety covalently attached to the R-group of the asparagine residue at amino acid position 38 in the amino acid sequence (a); and comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide.

[00526] In some embodiments, any of the above-described protease-resistant or protease-resistant, hyperglycosylated IFN- $\gamma$  variants is an [E38N, S40T, S99T]IFN-gamma

glycopeptide, where the [E38N, S40T, S99T]IFN-gamma glycopeptide is a variant of the mature, native IFN-gamma having (a) asparagine, threonine and threonine residues substituted for the native glutamic acid, serine and serine residues at amino acid positions 38, 40 and 99, respectively, in the amino acid sequence of IFN-gamma depicted in Figure 31 (where amino acids E38, S40, and S99 in the IFN- $\gamma$  amino acid sequence set forth in Figure 31 correspond to E41, S43, and S102, respectively, of the IFN- $\gamma$  amino acid sequence set forth in Figure 4); and (b) a carbohydrate moiety covalently attached to the R-group of the asparagine residue at amino acid position 38 in the amino acid sequence of (a), and optionally further having (c) a carbohydrate moiety covalently attached to the R-group of the asparagine residue at amino acid position 97 in the amino acid sequence of (a); and comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide.

[00527] In some embodiments, any of the above-described hyperglycosylated, protease-resistant IFN- $\gamma$  variants has increased stability compared to the unmodified (parent) cytokine, where the stability is assessed by measuring residual biological activity after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above. In other embodiments, any of the above-described protease-resistant IFN- $\gamma$  variants has increased biological activity compared to the unmodified (parent) cytokine, after incubation with either a mixture of proteases, individual proteases, blood lysate, or serum, as described above.

#### **Erythropoietin polypeptide variants**

[00528] In other embodiments, the hyperglycosylated, protease-resistant cytokine variant is a modified erythropoietin cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:201 (as set forth in Figure 7) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified erythropoietin. In some of these embodiments, the modified erythropoietin is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 201 (as set forth in Figure 7), corresponding to any of amino acid positions: 43, 45, 48, 49, 52, 53, 55, 72, 75, 76, 123, 129, 130, 131, 162, and 165, where the mutations include insertions, deletions and replacements of the native amino acid residue(s). In particular embodiments, the replacements are selected from among amino acid substitutions in SEQ ID NO:201, set forth in Table 4, below, where the first amino acid listed is substituted by the second amino acid at the position indicated; and where the variant further comprises an amino



acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

**Table 4**

1.	D43Q	14.	E55N	27.	L130V
2.	D43N	15.	E55H	28.	L130I
3.	K45Q	16.	E72Q	29.	R131H
4.	K45N	17.	E72N	30.	R131Q
5.	F48I	18.	E72H	31.	R162H
6.	F48V	19.	L75V	32.	R162Q
7.	Y49H	20.	L75I	33.	D165Q
8.	Y49I	21.	R76H	34.	D165N
9.	K52Q	22.	R76Q	35.	P121S
10.	K52N	23.	D123Q	36.	P121A
11.	R53H	24.	D123N	37.	P122S
12.	R53Q	25.	P129S	38.	P122A
13.	E55Q	26.	P129A		

**[00529]** In other embodiments, the modified erythropoietin comprises an amino acid sequence corresponding to any of SEQ ID NOS: 940-977, and further comprises one or more glycosylation sites not found in the parent polypeptide.

#### **GM-CSF polypeptide variants**

**[00530]** In other embodiments, hyperglycosylated, the protease-resistant cytokine variant is a modified GM-CSF cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:202 (as set forth in Figure 8) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described erythropoietin polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified GM-CSF. In some of these embodiments, the modified GM-CSF is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 202 (as set forth in Figure 8), corresponding to any of amino acid positions: 38, 41, 45, 46, 48, 49, 51, 60, 63, 67, 92, 93, 119, 120, 123, and 124, where the mutations include insertions, deletions and replacements of the native amino acid residue(s). In particular embodiments, the replacements are selected from among amino acid substitutions in SEQ ID NO:202, set forth in Table 5, below, where the first amino acid listed is substituted by the second amino acid at the position indicated; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

**Table 5**

1. E38Q	14. L49V	27. P92A
2. E38N	15. L49I	28. E93Q
3. E38H	16. E51Q	29. E93N
4. E41Q	17. E51N	30. E93H
5. E41N	18. E51H	31. F119I
6. E41H	19. E60Q	32. F119V
7. E45Q	20. E60N	33. D120Q
8. E45N	21. E60H	34. D120N
9. E45H	22. K63Q	35. E123Q
10. M46V	23. K63N	36. E123N
11. M46I	24. R67H	37. E123H
12. D48Q	25. R67Q	38. P124S
13. D48N	26. P92S	39. P124A

[00531] In other embodiments, the modified GM-CSF comprises an amino acid sequence corresponding to any of SEQ ID NOs: 362-400, and further comprises one or more glycosylation sites not found in the parent polypeptide.

#### **G-CSF polypeptide variants**

[00532] In other embodiments, the hyperglycosylated, protease-resistant cytokine variant is a modified G-CSF cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:210 (as set forth in Figure 5) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\alpha$ 2b polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified G-CSF. In some of these embodiments, the modified G-CSF is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO:210 (as set forth in Figure 5), corresponding to any of amino acid positions: 61, 63, 68, 72, 86, 96, 100, 101, 131, 133, 135, 147, 169, 172, and 177, where the mutations include insertions, deletions and replacements of the native amino acid residue(s). In particular embodiments, the replacements are selected from among amino acid substitutions in SEQ ID NO:210, set forth in Table 6, below, where the first amino acid listed is substituted by the second amino acid at the position indicated; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

**Table 6**

1.	W61S	12.	E96N	23.	P135S
2.	W61H	13.	E96H	24.	P135A
3.	P63S	14.	P100S	25.	F147I
4.	P63A	15.	P100A	26.	F147V
5.	P68S	16.	E101Q	27.	R169H
6.	P68A	17.	E101N	28.	R169Q
7.	L72V	18.	E101H	29.	R172H
8.	L72I	19.	P131S	30.	R172Q
9.	F86I	20.	P131A	31.	P177S
10.	F86V	21.	L133V	32.	P177A
11.	E96Q	22.	L133I		

[00533] In other embodiments, the modified G-CSF comprises an amino acid sequence corresponding to any of SEQ ID NOs: 631-662, and further comprises one or more glycosylation sites not found in the parent polypeptide.

#### **Human growth hormone polypeptide variants**

[00534] In other embodiments, the hyperglycosylated, protease-resistant cytokine variant is a modified human growth hormone (hGH) cytokine, comprising one or more amino acid replacements at one or more target positions in SEQ ID NO:216 (as set forth in Figure 6) corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described G-CSF polypeptide variant, where the replacement(s) lead to greater resistance to proteases, as assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified hGH. In some of these embodiments, the modified hGH is selected from among proteins comprising one or more single amino acid replacements at one or more target positions in SEQ ID NO: 216 (as set forth in Figure 6), corresponding to any of amino acid positions: 56, 59, 64, 65, 66, 88, 92, 94, 101, 129, 130, 133, 134, 140, 143, 145, 146, 147, 183, and 186, where the mutations include insertions, deletions and replacements of the native amino acid residue(s). In particular embodiments, the replacements are selected from among amino acid substitutions in SEQ ID NO:216, set forth in Table 7, below, where the first amino acid listed is substituted by the second amino acid at the position indicated; where the variant further comprises an amino acid sequence that differs from the amino acid sequence of the parent polypeptide to the extent that the variant comprises one or more glycosylation sites not found in the parent polypeptide.

Table 7

1. E56Q	17. F92I	33. K140N
2. E56N	18. F92V	34. Y143H
3. E56H	19. R94H	35. Y143I
4. P59S	20. R94Q	36. K145Q
5. P59A	21. L101V	37. K145N
6. R64H	22. L101I	38. F146I
7. R64Q	23. E129Q	39. F146V
8. E65Q	24. E129N	40. D147Q
9. E65N	25. E129H	41. D147N
10. E65H	26. D130Q	42. R183H
11. E66Q	27. D130N	43. R183Q
12. E66N	28. P133S	44. E186Q
13. E66H	29. P133A	45. E186N
14. E88Q	30. R134H	46. E186H
15. E88N	31. R134Q	
16. E88H	32. K140Q	

[00535] In other embodiments, the modified hGH comprises an amino acid sequence corresponding to any of SEQ ID NOs: 850-895, and further comprises one or more glycosylation sites not found in the parent polypeptide.

[00536] In other embodiments, the hyperglycosylated, protease-resistant cytokine variant is a modified cytokine that exhibits greater resistance to proteolysis, compared to a corresponding unmodified (parent) cytokine, where the modified cytokine comprises one or more amino acid replacements at one or more target positions on the cytokine corresponding to a structurally-related modified amino acid position within the 3-dimensional structure of an above-described IFN- $\beta$  polypeptide variant. The amino acid replacement(s) lead to greater resistance to proteolysis, compared to the unmodified (parent) cytokine. Increased resistance to proteolysis is assessed by incubation with a protease or with a blood lysate or by incubation with serum (as described above), compared to the unmodified hGH.

#### **Additional modifications**

[00537] Typically, a protease-resistant or protease-resistant, hyperglycosylated polypeptide variant will have an amino acid sequence that is substantially similar to the amino acid sequence of a parent polypeptide. For example, a hyperglycosylated, protease-resistant polypeptide variant can have an amino acid sequence that differs by at least one amino acid, and may differ by at least two but not more than about ten amino acids, compared to the amino acid sequence of a parent polypeptide. The sequence changes may be substitutions, insertions or deletions. Scanning mutations that systematically introduce alanine, or other residues, may be used to determine key amino acids. Specific amino acid substitutions of interest include conservative and non-conservative changes. Conservative amino acid substitutions typically

include substitutions within the following groups: (glycine, alanine); (valine, isoleucine, leucine); (aspartic acid, glutamic acid); (asparagine, glutamine); (serine, threonine); (lysine, arginine); or (phenylalanine, tyrosine).

[00538] Additional modifications of interest that may or may not alter the primary amino acid sequence of a parent protein therapeutic include chemical derivatization of polypeptides, e.g., acetylation, or carboxylation; changes in amino acid sequence that make the protein susceptible to PEGylation; and the like. A hyperglycosylated, protease-resistant polypeptide variant may be modified with one or more polyethylene glycol moieties (PEGylated). In one embodiment, the invention contemplates the use of polypeptide variants with one or more non-naturally occurring pegylation sites that are engineered to provide PEG-derivatized polypeptides with reduced serum clearance. Also embraced are sequences that have phosphorylated amino acid residues, e.g., phosphotyrosine, phosphoserine, or phosphothreonine.

[00539] Also suitable for use in connection with the present invention are polypeptides that have been modified using ordinary chemical techniques so as to improve their resistance to proteolytic degradation, to optimize solubility properties, or to render them more suitable as a therapeutic agent. For examples, the backbone of the peptide may be cyclized to enhance stability (see, for example, Friedler *et al.* 2000, *J. Biol. Chem.* 275:23783-23789). Analogs may be used that include residues other than naturally occurring L-amino acids, e.g., D-amino acids or non-naturally occurring synthetic amino acids. The protein may be pegylated to enhance stability.

[00540] Modifications of interest that may or may not alter the primary amino acid sequence include chemical derivatization of polypeptides, e.g., acetylation, or carboxylation; changes in amino acid sequence that make the protein susceptible to PEGylation (addition of a polyethylene glycol moiety); and the like. In one embodiment, the invention contemplates the use of synthetic Type I interferon receptor agonist variants, hyperglycosylated, protease-resistant polypeptide variants that further include one or more non-naturally occurring pegylation sites that are engineered to provide PEG-derivatized polypeptides with reduced serum clearance. Thus, the invention includes PEGylated synthetic Type I interferon receptor polypeptide agonist. Also included are modifications of glycosylation, e.g., those made by modifying the glycosylation patterns of a polypeptide during its synthesis and processing or in further processing steps; e.g., by exposing the polypeptide to enzymes that affect glycosylation, such as mammalian glycosylating or deglycosylating enzymes. The invention contemplates the use of any PEGylated hyperglycosylated, PEGylated protease-resistant and PEGylated

pretease-resistant hyperglycosylated polypeptide variants. Also embraced are sequences that have phosphorylated amino acid residues, e.g., phosphotyrosine, phosphoserine, or phosphothreonine.

#### Fusion proteins

- [00541] In some embodiments, a hyperglycosylated, protease-resistant polypeptide variant further comprises a heterologous polypeptide (e.g., a fusion partner) to form a fusion protein. Suitable fusion partners include peptides and polypeptides that confer enhanced stability *in vivo* (e.g., enhanced serum half-life); provide ease of purification, e.g., (His)<sub>n</sub>, e.g., 6His, and the like; provide for secretion of the fusion protein from a cell; provide an epitope tag, e.g., GST, hemagglutinin (HA; e.g., CYPYDVPDYA; SEQ ID NO:1304), FLAG (e.g., DYKDDDDK; SEQ ID NO:1305), c-myc (e.g., CEQKLISEEDL; SEQ ID NO:1306), and the like; provide a detectable signal, e.g., an enzyme that generates a detectable product (e.g.,  $\beta$ -galactosidase, luciferase), or a protein that is itself detectable, e.g., a green fluorescent protein, etc.; provides for multimerization, e.g., a multimerization domain such as an Fc portion of an immunoglobulin; and the like.
- [00542] A fusion protein may comprise an amino acid sequence that provides for secretion of the fusion protein from the cell. Those skilled in the art are aware of such secretion signal sequences. Secretion signals that are suitable for use in bacteria include, but are not limited to, the secretion signal of Braun's lipoprotein of *E. coli*, *S. marcescens*, *E. amylosora*, *M. morganii*, and *P. mirabilis*, the TraT protein of *E. coli* and Salmonella; the penicillinase (PenP) protein of *B. licheniformis* and *B. cereus* and *S. aureus*; pullulanase proteins of *Klebsiella pneumoniae* and *Klebsiella aerogenes*; *E. coli* lipoproteins 1pp-28, Pal, Rp1A, Rp1B, OsmB, NlpB, and Orl17; chitinase protein of *V. harseyi*; the  $\beta$ -1,4-endoglucanase protein of *Pseudomonas solanacearum*, the Pal and Pcp proteins of *H. influenzae*; the OprI protein of *P. aeruginosa*; the MalX and AmiA proteins of *S. pneumoniae*; the 34 kda antigen and TpmA protein of *Treponema pallidum*; the P37 protein of *Mycoplasma hyorhina*; the neutral protease of *Bacillus amyloliquefaciens*; and the 17 kda antigen of *Rickettsia rickettsii*. Secretion signal sequences suitable for use in yeast are known in the art, and can be used. See, e.g., U.S. Patent No. 5,712,113.
- [00543] In some embodiments, a signal peptide from IFN- $\alpha$ 14 is used. In other embodiments, a signal peptide from IFN- $\beta$  is used. Examples of synthetic Type I interferon receptor polypeptide agonist comprising an IFN- $\alpha$ 14 or an IFN- $\beta$  signal peptide are provided in Example 2. Such signal peptides provide for secretion from a mammalian cell.

[00544] In some embodiments, a hyperglycosylated, protease-resistant polypeptide variant comprises a fusion partner and a protease cleavage site that is positioned between the fusion partner and the remainder of the polypeptide variant.

[00545] Proteolytic cleavage sites are known to those skilled in the art; a wide variety are known and have been described amply in the literature, including, e.g., Handbook of Proteolytic Enzymes (1998) AJ Barrett, ND Rawlings, and JF Woessner, eds., Academic Press. Proteolytic cleavage sites include, but are not limited to, an enterokinase cleavage site: (Asp)<sub>4</sub>Lys (SEQ ID NO:1307); a factor Xa cleavage site: Ile-Glu-Gly-Arg (SEQ ID NO:1308); a thrombin cleavage site, e.g., Leu-Val-Pro-Arg-Gly-Ser (SEQ ID NO:1309); a renin cleavage site, e.g., His-Pro-Phe-His-Leu-Val-Ile-His (SEQ ID NO:1310); a collagenase cleavage site, e.g., X-Gly-Pro (where X is any amino acid); a trypsin cleavage site, e.g., Arg-Lys; a viral protease cleavage site, such as a viral 2A or 3C protease cleavage site, including, but not limited to, a protease 2A cleavage site from a picornavirus (see, e.g., Sommergruber et al. (1994) *Viol.* 198:741-745), a Hepatitis A virus 3C cleavage site (see, e.g., Schultheiss et al. (1995) *J. Virol.* 69:1727-1733), human rhinovirus 2A protease cleavage site (see, e.g., Wang et al. (1997) *Biochem. Biophys. Res. Comm.* 235:562-566), and a picornavirus 3 protease cleavage site (see, e.g., Walker et al. (1994) *Biotechnol.* 12:601-605).

**Preparation of a hyperglycosylated, protease-resistant polypeptide variant**

[00546] A subject synthetic Type I interferon receptor polypeptide agonist is conveniently prepared using any known method, including chemical synthesis methods, production by standard recombinant techniques, and combinations thereof. For example, a subject synthetic Type I interferon receptor polypeptide agonist can be synthesized using an automated solid-phase tert-butyloxycarbonyl and benzyl protection strategy. A subject synthetic Type I interferon receptor polypeptide agonist can be synthesized by native chemical ligation, e.g., fragments of from about 15 to about 40 amino acids in length (e.g., fragments of from about 15 to about 20, from about 20 to about 25, from about 25 to about 30, from about 30 to about 35, or from about 35 to about 40 amino acids in length) can be synthesized using standard methods of chemical synthesis, and the fragments ligated, using a process as described in Dawson, et al. (1994) *Science* 266:776-779. The purity of synthesized polypeptides may be assessed by reverse-phase high performance liquid chromatography (HPLC) and isoelectric focusing. The primary structures of the ligands may be verified by Edman sequencing methods.

[00547] In many embodiments, an expression vector comprising a nucleotide sequence that encodes a subject synthetic Type I interferon receptor polypeptide agonist is prepared, using conventional methods, and is introduced into a host cell, particularly a eukaryotic cell that is

capable of glycosylating proteins. The expression vector provides for production of the subject synthetic Type I interferon receptor polypeptide agonist in the host cell. Thus, the present invention provides a method for producing a synthetic Type I interferon receptor polypeptide agonist, the method comprising culturing a eukaryotic host cell, which host cell comprises a subject recombinant expression vector, under conditions that favor production of the synthetic Type I interferon receptor polypeptide agonist; and isolating the synthetic Type I interferon receptor polypeptide agonist from the culture. The subject polypeptide agonist may be isolated and purified to greater than 80%, greater than 90%, greater than 95%, greater than 98%, or greater than 99% purity.

[00548] The polypeptides may be expressed in prokaryotes or eukaryotes in accordance with conventional ways, depending upon the purpose for expression. As noted above, in many embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is synthesized in a eukaryotic cell. For large scale production of the protein, a unicellular organism, such as *S. cerevisiae*, insect cells in combination with baculovirus vectors, or cells of a higher organism such as vertebrates, particularly mammals, e.g. COS 7 cells, CHO cells, HEK293 cells, and the like, may be used as the expression host cells. In many embodiments, it is desirable to express the gene in eukaryotic cells, where the protein will benefit from native folding and post-translational modifications.

[00549] With the availability of the protein or fragments thereof in large amounts, by employing an expression host, the protein may be isolated and purified in accordance with conventional ways. A lysate may be prepared of the expression host and the lysate purified using HPLC, hydrophobic interaction chromatography (HIC), anion exchange chromatography, cation exchange chromatography, size exclusion chromatography, ultrafiltration, gel electrophoresis, affinity chromatography, or other purification technique.

[00550] A subject synthetic Type I interferon receptor polypeptide agonist may also be isolated and purified from cell culture supernatants or from cell lysates using conventional methods. For example, a lysate may be prepared of the expression host and the lysate purified using HPLC, hydrophobic interaction chromatography (HIC), anion exchange chromatography, cation exchange chromatography, size exclusion chromatography, ultrafiltration, gel electrophoresis, affinity chromatography, or other purification technique. For the most part, the compositions which are used will comprise at least 20% by weight of the desired product, more usually at least about 75% by weight, preferably at least about 95% by weight, and for therapeutic purposes, usually at least about 99.5% by weight, in relation to contaminants



related to the method of preparation of the product and its purification. Usually, the percentages will be based upon total protein.

[00551] In many embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is purified, e.g., a subject synthetic Type I interferon receptor polypeptide agonist is free of other, non-subject proteins, and is free other macromolecules (e.g., carbohydrates, lipids, etc.). In many embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is at least about 75% pure, at least about 80% pure, at least about 85% pure, at least about 90% pure, at least about 95% pure, at least about 98% pure, or at least about 99% pure, or more than 99% pure. Methods of determining whether a protein is free of other proteins and other macromolecules are known in the art.

[00552] The hyperglycosylated, protease-resistant polypeptide variants may be prepared by recombinant methods, using conventional techniques known in the art. The particular sequence and the manner of preparation will be determined by convenience, economics, purity required, and the like.

[00553] Typically, an oligonucleotide encoding the amino acid sequence of the desired polypeptide variant is prepared by chemical synthesis, e.g., by using an oligonucleotide synthesizer, wherein oligonucleotides are designed based on the amino acid sequence of the desired polypeptide, and in many embodiments, selecting those codons that are favored in the host cell in which the recombinant polypeptide will be produced. For example, several small oligonucleotides coding for portions of the desired polypeptide may be synthesized and assembled by PCR, ligation or ligation chain reaction (LCR). The individual oligonucleotides typically contain 5' or 3' overhangs for complementary assembly. Once assembled, the nucleotide sequence encoding the polypeptide variant is inserted into a recombinant vector and operably linked to control sequences necessary for expression of the desired nucleic acid, and subsequent production of the subject polypeptide, in the desired transformed host cell.

[00554] In some embodiments, a desired nucleic acid is generated such that at least about 10%, at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, or at least about 90%, or more, of the codons are codons that are preferred in human sequences. See, e.g., **Table 8**, below.

**Table 8: Codon Usage in Human. Molecular Cloning: A Laboratory Manual. Sambrook J. and Russell D. W. Third Edition ©2001 by Cold Spring Harbor Press.**

AMINO ACID	FREQUENCY IN HUMAN PROTEINS (%) <sup>a</sup>	CODONS AND THEIR USAGE IN HUMAN PROTEINS (%) <sup>b</sup>	
Alanine	6.99	GCU (28.0) GCA (20.0)	GCC (41.6) GCG (10.3)
Arginine	5.28	CGU (8.9) CGA (5.4) AGA (9.9)	CGC (21.4) CGG (10.4) AGG (11.1)
Asparagine	3.92	AAU (42.3)	AAC (57.7)
Aspartic Acid	5.07	GAU (42.8)	GAC (57.2)
Cysteine	2.44	UGU (40.6)	UGC (59.4)
Glutamic Acid	6.82	GAA (39.2)	GAG (60.7)
Glutamine	4.47	CAA (24.8)	CAG (75.2)
Glycine	7.10	GGU (15.8) GGA (24.1)	GGC (35.8) GGG (24.3)
Histidine	2.35	CAU (39.6)	CAC (60.4)
Isoleucine	4.50	AUU (33.1) AUA (12.9)	AUC (54.0)
Leucine	9.56	UUA (5.5) CUU (11.1) CUA (6.5)	UUG (11.5) CUC (20.8) CUG (44.5)
Lysine	5.71	AAA (38.9)	AAG (61.1)
Methionine	2.23	AUG (100)	
Phenylalanine	3.84	UUU (41.1)	UUC (58.2)
Proline	5.67	CCU (27.3) CCA (25.7)	CCC (35.2) CCG (11.6)
Serine	7.25	UCU (18.3) UCA (12.9) AGU (13.2)	UCC (23.7) UCG (5.9) AGC (25.9)
Threonine	5.68	ACU (22.4) ACA (25.4)	ACC (40.5) ACG (11.8)
Tryptophan	1.38	UGG (100)	
Tyrosine	3.13	UAU (40.0)	UAC (60.0)
Valine	6.35	GUU (16.4) GUA (9.3)	GUC (25.7) GUG (48.7)

[00555] The polypeptide-encoding nucleic acid molecules are generally propagated by placing the molecule in a vector. Viral and non-viral vectors are used, including plasmids. The choice of plasmid will depend on the type of cell in which propagation is desired and the purpose of propagation. Certain vectors are useful for amplifying and making large amounts of the desired DNA sequence.

[00556] A recombinant expression vector is useful for effecting expression of a polypeptide-encoding nucleic acid molecule in a cell, e.g., for production of a hyperglycosylated, protease-resistant polypeptide variant. The choice of appropriate vector is well within the skill of the art. Many such vectors are available commercially.

[00557] Expression vectors are suitable for expression in cells in culture. These vectors will generally include regulatory sequences ("control sequences" or "control regions") which are

necessary to effect the expression of a desired polynucleotide to which they are operably linked.

[00558] Expression vectors generally have convenient restriction sites located near the promoter sequence to provide for the insertion of nucleic acid sequences encoding a desired protein or other protein. A selectable marker operative in the expression host may be present. Expression vectors may be used for the production of fusion proteins, where the exogenous fusion peptide provides additional functionality, i.e. increased protein synthesis, stability, reactivity with defined antisera, an enzyme marker, e.g.  $\beta$ -galactosidase, luciferase, etc.

[00559] Expression cassettes may be prepared that comprise a transcription initiation region, a promoter region (e.g., a promoter that is functional in a eukaryotic cell), a desired polynucleotide, and a transcriptional termination region. After introduction of the DNA, the cells containing the construct may be selected by means of a selectable marker, the cells expanded and then used for expression.

[00560] The expression cassettes may be introduced into a variety of vectors suitable for eukaryotic host cell expression, e.g. plasmid, HAC, YAC, vectors derived from animal viruses, e.g., Moloney's murine leukemia virus, SV40, vaccinia virus, baculovirus, retroviruses, or plant viruses, e.g., cauliflower mosaic virus, tobacco mosaic virus, and the like, where the vectors are normally characterized by the ability to provide selection of cells comprising the expression vectors. The vectors may provide for extrachromosomal maintenance, particularly as plasmids or viruses, or for integration into the host chromosome. Where extrachromosomal maintenance is desired, an origin sequence is provided for the replication of the plasmid, which may be low- or high copy-number. A wide variety of markers are available for selection, particularly those which protect against toxins, more particularly against antibiotics. The particular marker that is chosen is selected in accordance with the nature of the host, where in some cases, complementation may be employed with auxotrophic hosts. Introduction of the DNA construct into a host cell may use any convenient method, e.g., calcium-precipitated DNA, electroporation, fusion, transfection, infection with viral vectors, biolistics, etc.

[00561] The present invention further contemplates the production of hyperglycosylated, protease-resistant polypeptide variants in genetically modified host cells, which may be isolated host cells, comprising a polynucleotide encoding the polypeptide variant, or, in some embodiments, an expression vector capable of expressing such a polynucleotide. Suitable host cells are eukaryotic cells, including insect cells in combination with baculovirus vectors, yeast cells, such as *Saccharomyces cerevisiae*, or cells of a higher organism such as vertebrates, including amphibians (e.g., *Xenopus laevis* oocytes), and mammals, particularly mammals, e.g.

COS cells, CHO cells, HEK293 cells, MA-10 cells, and the like, may be used as the expression host cells. In particular, the host cell is a eukaryotic host cell that is capable of glycosylating a protein.

[00562] The hyperglycosylated, protease-resistant polypeptide variant can be harvested from the production host cells and then isolated and purified in accordance with conventional methods of recombinant synthesis. A lysate may be prepared of the expression host and the lysate purified using high performance liquid chromatography, exclusion chromatography, gel electrophoresis, affinity chromatography, or other purification technique. For the most part, the compositions which are used will comprise at least 20% by weight of the desired product, more usually at least about 75% by weight, preferably at least about 95% by weight, and for therapeutic purposes, usually at least about 99.5% by weight, in relation to contaminants related to the method of preparation of the product and its purification. Usually, the percentages will be based upon total protein.

PEGylated Type I interferon receptor polypeptide agonists

[00563] As noted above, in some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist is modified with one or more polyethylene glycol moieties, i.e., PEGylated. The PEG molecule is conjugated to one or more amino acid side chains of the subject polypeptide agonist. In some embodiments, a subject PEGylated polypeptide agonist contains a PEG moiety on only one amino acid. In other embodiments, a subject PEGylated polypeptide agonist contains a PEG moiety on two or more amino acids, e.g., the subject PEGylated polypeptide agonist contains a PEG moiety attached to two, three, four, five, six, seven, eight, nine, or ten different amino acid residues.

[00564] A subject polypeptide may be coupled directly to PEG (i.e., without a linking group) through an amino group, a sulfhydryl group, a hydroxyl group, or a carboxyl group.

[00565] In some embodiments, the PEGylated subject polypeptide is PEGylated at or near the amino terminus (N-terminus) of the subject polypeptide, e.g., the PEG moiety is conjugated to the subject polypeptide at one or more amino acid residues from amino acid 1 through amino acid 4, or from amino acid 5 through about 10. In other embodiments, the PEGylated subject polypeptide is PEGylated at one or more amino acid residues from about 10 to about 28. In other embodiments, the PEGylated subject polypeptide is PEGylated at or near the carboxyl terminus (C-terminus) of the subject polypeptide, e.g., at one or more residues from amino acids 156-166, or from amino acids 150 to 155. In other embodiments, the PEGylated subject polypeptide is PEGylated at one or more amino acid residues at one or more residues from amino acids 100-114.

[00566] The polyethylene glycol derivatization of amino acid residues at or near the receptor-binding and/or active site domains of the subject protein can disrupt the functioning of these domains. In certain embodiments of the invention, amino acids at which PEGylation is to be avoided include amino acid residues from amino acid 30 to amino acid 40; and amino acid residues from amino acid 113 to amino acid 149.

[00567] In some embodiments, PEG is attached to the subject polypeptide via a linking group. The linking group is any biocompatible linking group, where "biocompatible" indicates that the compound or group is non-toxic and may be utilized *in vitro* or *in vivo* without causing injury, sickness, disease, or death. PEG can be bonded to the linking group, for example, via an ether bond, an ester bond, a thiol bond or an amide bond. Suitable biocompatible linking groups include, but are not limited to, an ester group, an amide group, an imide group, a carbamate group, a carboxyl group, a hydroxyl group, a carbohydrate, a succinimide group (including, for example, succinimidyl succinate (SS), succinimidyl propionate (SPA), succinimidyl butanoate (SBA), succinimidyl carboxymethylate (SCM), succinimidyl succinamide (SSA) or N-hydroxy succinimide (NHS)), an epoxide group, an oxycarbonylimidazole group (including, for example, carbonyldimidazole (CDI)), a nitro phenyl group (including, for example, nitrophenyl carbonate (NPC) or trichlorophenyl carbonate (TPC)), a trysylate group, an aldehyde group, an isocyanate group, a vinylsulfone group, a tyrosine group, a cysteine group, a histidine group or a primary amine.

[00568] Methods for making succinimidyl propionate (SPA) and succinimidyl butanoate (SBA) ester-activated PEGs are described in U.S. Pat. No. 5,672,662 (Harris, et al.) and WO 97/03106.

[00569] Methods for attaching a PEG to a polypeptide are known in the art, and any known method can be used. See, for example, by Park et al, *Anticancer Res.*, 1:373-376 (1981); Zaplisky and Lee, *Polyethylene Glycol Chemistry: Biotechnical and Biomedical Applications*, J. M. Harris, ed., Plenum Press, NY, Chapter 21 (1992); U.S. Patent No. 5,985,265; U.S. Pat. No. 5,672,662 (Harris, et al.) and WO 97/03106.

[00570] In many embodiments, the PEG is a monomethoxyPEG molecule that reacts with primary amine groups on the subject polypeptide. Methods of modifying polypeptides with monomethoxy PEG via reductive alkylation are known in the art. See, e.g., Chamow et al. (1994) *Bioconj. Chem.* 5:133-140.

*Polyethylene glycol*

[00571] Polyethylene glycol suitable for conjugation to a subject polypeptide is soluble in water at room temperature, and has the general formula  $R(O-CH_2-CH_2)_nO-R$ , where R is hydrogen or

a protective group such as an alkyl or an alkanol group, and where n is an integer from 1 to 1000. Where R is a protective group, it generally has from 1 to 8 carbons.

- [00572] In many embodiments, PEG has at least one hydroxyl group, e.g., a terminal hydroxyl group, which hydroxyl group is modified to generate a functional group that is reactive with an amino group, e.g., an epsilon amino group of a lysine residue, a free amino group at the N-terminus of a polypeptide, or any other amino group such as an amino group of asparagine, glutamine, arginine, or histidine.
- [00573] In other embodiments, PEG is derivatized so that it is reactive with free carboxyl groups in the subject polypeptide, e.g., the free carboxyl group at the carboxyl terminus of the subject polypeptide. Suitable derivatives of PEG that are reactive with the free carboxyl group at the carboxyl-terminus of a subject polypeptide include, but are not limited to PEG-amine, and hydrazine derivatives of PEG (e.g., PEG-NH-NH<sub>2</sub>).
- [00574] In other embodiments, PEG is derivatized such that it comprises a terminal thiocarboxylic acid group, -COSH, which selectively reacts with amino groups to generate amide derivatives. Because of the reactive nature of the thio acid, selectivity of certain amino groups over others is achieved. For example, -SH exhibits sufficient leaving group ability in reaction with N-terminal amino group at appropriate pH conditions such that the ε-amino groups in lysine residues are protonated and remain non-nucleophilic. On the other hand, reactions under suitable pH conditions may make some of the accessible lysine residues to react with selectivity.
- [00575] In other embodiments, the PEG comprises a reactive ester such as an N-hydroxy succinimide at the end of the PEG chain. Such an N-hydroxysuccinimide-containing PEG molecule reacts with select amino groups at particular pH conditions such as neutral 6.5-7.5. For example, the N-terminal amino groups may be selectively modified under neutral pH conditions. However, if the reactivity of the reagent were extreme, accessible-NH<sub>2</sub> groups of lysine may also react.
- [00576] The PEG can be conjugated directly to the subject polypeptide, or through a linker. In some embodiments, a linker is added to the subject polypeptide, forming a linker-modified polypeptide. Such linkers provide various functionalities, e.g., reactive groups such as sulfhydryl, amino, or carboxyl groups to couple a PEG reagent to the linker-modified polypeptide.
- [00577] In some embodiments, the PEG conjugated to the subject polypeptide is linear. In other embodiments, the PEG conjugated to the subject polypeptide is branched. Branched PEG derivatives such as those described in U.S. Pat. No. 5,643,575, "star-PEG's" and multi-armed PEG's such as those described in Shearwater Polymers, Inc. catalog "Polyethylene Glycol

Derivatives 1997-1998." Star PEGs are described in the art including, e.g., in U.S. Patent No. 6,046,305.

[00578] PEG having a molecular weight in a range of from about 2 kDa to about 100 kDa, is generally used, where the term "about," in the context of PEG, indicates that in preparations of polyethylene glycol, some molecules will weigh more, some less, than the stated molecular weight. For example, PEG suitable for conjugation to a subject polypeptide has a molecular weight of from about 2 kDa to about 5 kDa, from about 5 kDa to about 10 kDa, from about 10 kDa to about 15 kDa, from about 15 kDa to about 20 kDa, from about 20 kDa to about 25 kDa, from about 25 kDa to about 30 kDa, from about 30 kDa to about 40 kDa, from about 40 kDa to about 50 kDa, from about 50 kDa to about 60 kDa, from about 60 kDa to about 70 kDa, from about 70 kDa to about 80 kDa, from about 80 kDa to about 90 kDa, or from about 90 kDa to about 100 kDa.

Populations of subject synthetic Type I interferon receptor polypeptide agonists

[00579] The instant invention provides a composition that comprises a population of synthetic Type I interferon receptor polypeptide agonists as described above. The subject composition comprises a population of subject polypeptides, wherein the population comprises at least two different subject synthetic Type I interferon receptor polypeptide agonists (e.g., polypeptide agonists that differ from one another in amino acid sequence by at least one amino acid).

[00580] Generally, a given subject synthetic Type I interferon receptor polypeptide agonist represents from about 0.5% to about 99.5% of the total population of synthetic Type I interferon receptor polypeptide agonists in a population, e.g., a given modified synthetic Type I interferon receptor polypeptide agonist represents about 0.5%, about 1%, about 2%, about 3%, about 4%, about 5%, about 10%, about 15%, about 20%, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, about 95%, about 99%, or about 99.5% of the total population of synthetic Type I interferon receptor polypeptide agonists in a population.

**COMPOSITIONS**

[00581] The present invention provides compositions, including pharmaceutical compositions, comprising a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant, i.e., a polypeptide variant of a parent protein therapeutic that comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent protein therapeutic; and that includes (1) a carbohydrate moiety covalently attached to at least one non-native glycosylation site not found

in the parent protein therapeutic and/or (2) a carbohydrate moiety covalently attached to at least one native glycosylation site found but not glycosylated in the parent protein therapeutic. Compositions will comprise a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant; and one or more additional components, which are selected based in part on the use of the polypeptide variant. Suitable additional components include, but are not limited to, salts, buffers, solubilizers, stabilizers, detergents, protease-inhibiting agents, and the like.

[00582] In some embodiments, a subject composition comprises a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant and a pharmaceutically acceptable excipient. A wide variety of pharmaceutically acceptable excipients are known in the art and need not be discussed in detail herein. Pharmaceutically acceptable excipients have been amply described in a variety of publications, including, for example, A. Gennaro (2000) "Remington: The Science and Practice of Pharmacy," 20<sup>th</sup> edition, Lippincott, Williams, & Wilkins; Pharmaceutical Dosage Forms and Drug Delivery Systems (1999) H.C. Ansel et al., eds., 7<sup>th</sup> ed., Lippincott, Williams, & Wilkins; and Handbook of Pharmaceutical Excipients (2000) A.H. Kibbe et al., eds., 3<sup>rd</sup> ed. Amer. Pharmaceutical Assoc.

[00583] In pharmaceutical dosage forms, a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant is in some embodiments provided in the form of a pharmaceutically acceptable salts, used alone, or in appropriate association, as well as in combination, with other pharmaceutically active compounds.

Formulations suitable for injection

[00584] A subject synthetic Type I interferon receptor polypeptide agonist is in some embodiments formulated into a preparation suitable for injection (e.g., subcutaneous, intramuscular, intradermal, transdermal, or other injection routes) by dissolving, suspending or emulsifying the agonist in an aqueous solvent (e.g., saline, and the like) or a nonaqueous solvent, such as vegetable or other similar oils, synthetic aliphatic acid glycerides, esters of higher aliphatic acids or propylene glycol; and if desired, with conventional additives such as solubilizers, isotonic agents, suspending agents, emulsifying agents, stabilizers and preservatives.



Formulations for enteral delivery

- [00585] For oral preparations, a subject agent (e.g., a subject synthetic Type I interferon receptor polypeptide agonist) is formulated alone or in combination with appropriate additives to make tablets, powders, granules or capsules, for example, with conventional additives, such as lactose, mannitol, corn starch or potato starch; with binders, such as crystalline cellulose, cellulose derivatives, acacia, corn starch or gelatins; with disintegrators, such as corn starch, potato starch or sodium carboxymethylcellulose; with lubricants, such as talc or magnesium stearate; and if desired, with diluents, buffering agents, moistening agents, preservatives, and flavoring agents.
- [00586] Furthermore, a subject agonist can be made into suppositories by mixing with a variety of bases such as emulsifying bases or water-soluble bases. A subject agonist can be administered rectally via a suppository. The suppository can include vehicles such as cocoa butter, carbowaxes and polyethylene glycols, which melt at body temperature, yet are solidified at room temperature.
- [00587] Unit dosage forms for oral or rectal administration such as syrups, elixirs, and suspensions may be provided wherein each dosage unit, for example, teaspoonful, tablespoonful, tablet or suppository, contains a predetermined amount of the composition containing one or more active agents. Similarly, unit dosage forms for injection or intravenous administration may comprise the agonist(s) in a composition as a solution in sterile water, normal saline or another pharmaceutically acceptable carrier.
- [00588] For enteral delivery, a subject formulation will in some embodiments include an enteric-soluble coating material. Suitable enteric-soluble coating material include hydroxypropyl methylcellulose acetate succinate (HPMCAS), hydroxypropyl methyl cellulose phthalate (HPMCP), cellulose acetate phthalate (CAP), polyvinyl phthalic acetate (PVPA), Eudragit™, and shellac.
- [00589] As one non-limiting example of a suitable oral formulation, a subject synthetic Type I interferon receptor polypeptide agonist can be formulated together with one or more pharmaceutical excipients and coated with an enteric coating, as described in U.S. Patent No. 6,346,269. For example, a solution comprising a solvent, a subject synthetic Type I interferon receptor polypeptide agonist, and a stabilizer is coated onto a core comprising pharmaceutically acceptable excipients, to form an active agent-coated core; a sub-coating layer is applied to the active agent-coated core, which is then coated with an enteric coating layer. The core generally includes pharmaceutically inactive components such as lactose, a starch, mannitol, sodium carboxymethyl cellulose, sodium starch glycolate, sodium chloride,

potassium chloride, pigments, salts of alginic acid, talc, titanium dioxide, stearic acid, stearate, micro-crystalline cellulose, glycerin, polyethylene glycol, triethyl citrate, tributyl citrate, proparyl triacetate, dibasic calcium phosphate, tribasic sodium phosphate, calcium sulfate, cyclodextrin, and castor oil. Suitable solvents for the active agent include aqueous solvents. Suitable stabilizers include alkali-metals and alkaline earth metals, bases of phosphates and organic acid salts and organic amines. The sub-coating layer comprises one or more of an adhesive, a plasticizer, and an anti-tackiness agent. Suitable anti-tackiness agents include talc, stearic acid, stearate, sodium stearyl fumarate, glyceryl behenate, kaolin and aerosil. Suitable adhesives include polyvinyl pyrrolidone (PVP), gelatin, hydroxyethyl cellulose (HEC), hydroxypropyl cellulose (HPC), hydroxypropyl methyl cellulose (HPMC), vinyl acetate (VA), polyvinyl alcohol (PVA), methyl cellulose (MC), ethyl cellulose (EC), hydroxypropyl methyl cellulose phthalate (HPMCP), cellulose acetate phthalates (CAP), xanthan gum, alginic acid, salts of alginic acid, Eudragit™, copolymer of methyl acrylic acid/methyl methacrylate with polyvinyl acetate phthalate (PVAP). Suitable plasticizers include glycerin, polyethylene glycol, triethyl citrate, tributyl citrate, proparyl triacetate and castor oil. Suitable enteric-soluble coating material include hydroxypropyl methylcellulose acetate succinate (HPMCAS), hydroxypropyl methyl cellulose phthalate (HPMCP), cellulose acetate phthalate (CAP), polyvinyl phthalic acetate (PVPA), Eudragit™ and shellac.

**[00590]** Suitable oral formulations also include a subject synthetic Type I interferon receptor polypeptide agonist formulated with any of the following: microgranules (see, e.g., U.S. Patent No. 6,458,398); biodegradable macromers (see, e.g., U.S. Patent No. 6,703,037); biodegradable hydrogels (see, e.g., Graham and McNeill (1989) *Biomaterials* 5:27-36); biodegradable particulate vectors (see, e.g., U.S. Patent No. 5,736,371); bioabsorbable lactone polymers (see, e.g., U.S. Patent No. 5,631,015); slow release protein polymers (see, e.g., U.S. Patent No. 6,699,504; Pelias Technologies, Inc.); a poly(lactide-co-glycolide/polyethylene glycol block copolymer (see, e.g., U.S. Patent No. 6,630,155; Atrix Laboratories, Inc.); a composition comprising a biocompatible polymer and particles of metal cation-stabilized agent dispersed within the polymer (see, e.g., U.S. Patent No. 6,379,701; Alkermes Controlled Therapeutics, Inc.); and microspheres (see, e.g., U.S. Patent No. 6,303,148; Octoplus, B.V.).

**[00591]** Suitable oral formulations also include a subject synthetic Type I interferon receptor polypeptide agonist formulated with any of the following: a carrier such as Emisphere® (Emisphere Technologies, Inc.); TIMERx, a hydrophilic matrix combining xanthan and locust bean gums which, in the presence of dextrose, form a strong binder gel in water (Penwest); Geminex™ (Penwest); Procise™ (GlaxoSmithKline); SAVIT™ (Mistral Pharma Inc.);

RingCap™ (Alza Corp.); Smatrix® (Smatrix Technologies, Inc.); SQZgel™ (MacroMed, Inc.); Geomatrix™ (Skye Pharma, Inc.); Oros® Tri-layer (Alza Corporation); and the like.

[00592] Also suitable for use are formulations such as those described in U.S. Patent No. 6,296,842 (Alkermes Controlled Therapeutics, Inc.); U.S. Patent No. 6,187,330 (Scios, Inc.); and the like.

Formulations for oral delivery

[00593] The present invention provides pharmaceutical compositions comprising a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant; and a pharmaceutical excipient suitable for oral delivery.

[00594] For oral preparations, a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant is formulated alone or in combination with appropriate additives to make tablets, powders, granules or capsules, for example, with conventional additives, such as lactose, mannitol, corn starch or potato starch; with binders, such as crystalline cellulose, cellulose derivatives, acacia, corn starch or gelatins; with disintegrators, such as corn starch, potato starch or sodium carboxymethylcellulose; with lubricants, such as talc or magnesium stearate; and if desired, with diluents, buffering agents, moistening agents, preservatives, and flavoring agents.

[00595] Unit dosage forms for oral administration such as syrups, elixirs, and suspensions may be provided wherein each dosage unit, for example, teaspoonful, tablespoonful, tablet, contains a predetermined amount of the composition containing one or more active agents.

[00596] For oral delivery, a subject formulation will in some embodiments include an enteric-soluble coating material. Suitable enteric-soluble coating material include hydroxypropyl methylcellulose acetate succinate (HPMCAS), hydroxypropyl methyl cellulose phthalate (HPMCP), cellulose acetate phthalate (CAP), polyvinyl phthalic acetate (PVPA), Eudragit™, and shellac.

[00597] As one non-limiting example of a suitable oral formulation, a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant can be formulated together with one or more pharmaceutical excipients and coated with an enteric coating, as described in U.S. Patent No. 6,346,269. For example, a solution comprising a solvent, a known hyperglycosylated, protease-resistant polypeptide

variant, and a stabilizer is coated onto a core comprising pharmaceutically acceptable excipients, to form an active agent-coated core; a sub-coating layer is applied to the active agent-coated core, which is then coated with an enteric coating layer. The core generally includes pharmaceutically inactive components such as lactose, a starch, mannitol, sodium carboxymethyl cellulose, sodium starch glycolate, sodium chloride, potassium chloride, pigments, salts of alginic acid, talc, titanium dioxide, stearic acid, stearate, micro-crystalline cellulose, glycerin, polyethylene glycol, triethyl citrate, tributyl citrate, propanyl triacetate, dibasic calcium phosphate, tribasic sodium phosphate, calcium sulfate, cyclodextrin, and castor oil. Suitable solvents for the active agent include aqueous solvents. Suitable stabilizers include alkali-metals and alkaline earth metals, bases of phosphates and organic acid salts and organic amines. The sub-coating layer comprises one or more of an adhesive, a plasticizer, and an anti-tackiness agent. Suitable anti-tackiness agents include talc, stearic acid, stearate, sodium stearyl fumarate, glyceryl behenate, kaolin and aerosil. Suitable adhesives include polyvinyl pyrrolidone (PVP), gelatin, hydroxyethyl cellulose (HEC), hydroxypropyl cellulose (HPC), hydroxypropyl methyl cellulose (HPMC), vinyl acetate (VA), polyvinyl alcohol (PVA), methyl cellulose (MC), ethyl cellulose (EC), hydroxypropyl methyl cellulose phthalate (HPMCP), cellulose acetate phthalates (CAP), xanthan gum, alginic acid, salts of alginic acid, Eudragit™, copolymer of methyl acrylic acid/methyl methacrylate with polyvinyl acetate phthalate (PVAP). Suitable plasticizers include glycerin, polyethylene glycol, triethyl citrate, tributyl citrate, propanyl triacetate and castor oil. Suitable enteric-soluble coating material include hydroxypropyl methylcellulose acetate succinate (HPMCAS), hydroxypropyl methyl cellulose phthalate (HPMCP), cellulose acetate phthalate (CAP), polyvinyl phthalic acetate (PVPA), Eudragit™ and shellac.

**[00598]** Suitable oral formulations also include a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant formulated with any of the following: microgranules (see, e.g., U.S. Patent No. 6,458,398); biodegradable macromers (see, e.g., U.S. Patent No. 6,703,037); biodegradable hydrogels (see, e.g., Graham and McNeill (1989) *Biomaterials* 5:27-36); biodegradable particulate vectors (see, e.g., U.S. Patent No. 5,736,371); bioabsorbable lactone polymers (see, e.g., U.S. Patent No. 5,631,015); slow release protein polymers (see, e.g., U.S. Patent No. 6,699,504; Pelias Technologies, Inc.); a poly(lactide-co-glycolide/polyethylene glycol block copolymer (see, e.g., U.S. Patent No. 6,630,155; Atrix Laboratories, Inc.); a composition comprising a biocompatible polymer and particles of metal cation-stabilized agent dispersed

within the polymer (see, e.g., U.S. Patent No. 6,379,701; Alkermes Controlled Therapeutics, Inc.); and microspheres (see, e.g., U.S. Patent No. 6,303,148; Octoplus, B.V.).

[00599] Suitable oral formulations also include a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant formulated with any of the following: a carrier such as Emisphere® (Emisphere Technologies, Inc.); TIMERx, a hydrophilic matrix combining xanthan and locust bean gums which, in the presence of dextrose, form a strong binder gel in water (Penwest); Geminex™ (Penwest); Procise™ (GlaxoSmithKline); SAVIT™ (Mistral Pharma Inc.); RingCap™ (Alza Corp.); Smatrix® (Smatrix Technologies, Inc.); SQZgel™ (MacroMed, Inc.); Geomatrix™ (Skye Pharma, Inc.); Oros® Tri-layer (Alza Corporation); and the like.

[00600] Also suitable for use are formulations such as those described in U.S. Patent No. 6,296,842 (Alkermes Controlled Therapeutics, Inc.); U.S. Patent No. 6,187,330 (Scios, Inc.); and the like.

[00601] Also suitable for use herein are formulations comprising an intestinal absorption enhancing agent. Suitable intestinal absorption enhancers include, but are not limited to, calcium chelators (e.g., citrate, ethylenediamine tetracetic acid); surfactants (e.g., sodium dodecyl sulfate, bile salts, palmitoylcarnitine, and sodium salts of fatty acids); toxins (e.g., zonula occludens toxin); and the like.

[00602] In one aspect, a subject synthetic Type I interferon receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant is in a first unit form of an orally delivered formulation. The known synthetic Type I interferon receptor polypeptide agonist, hyperglycosylated polypeptide variant, protease-resistant polypeptide variant, or hyperglycosylated, protease-resistant polypeptide variant is a variant of a parent protein therapeutic. In these embodiments, the first unit form comprises a first number of moles of the known synthetic Type I interferon receptor polypeptide agonist, hyperglycosylated polypeptide variant, protease-resistant polypeptide variant, or hyperglycosylated, protease-resistant polypeptide variant. The parent protein therapeutic is one that is typically administered at a dosage of a second number of moles of the parent protein therapeutic in a second unit form, where the second unit form is an immediate release formulation, e.g., an immediate release formulation that is suitable for subcutaneous injection. The parent protein therapeutic is delivered by subcutaneous bolus injection at a selected dosing frequency. The parent protein therapeutic must be proven to be effective in the treatment of a disease in a patient when

administered to the patient in the second unit form by subcutaneous bolus injection at the selected dosing frequency. The first number of moles in the first unit form is greater than the second number of moles in the second unit form. Nevertheless, when the first unit form is administered orally to the patient, the first number of moles of the known hyperglycosylated, protease-resistant polypeptide variant is released by the first unit form over a period of time that is no greater than the time interval between doses of the parent protein therapeutic in the selected dosing frequency.

[00603] In another aspect, the oral pharmaceutical composition of the invention comprises a first dose of the known synthetic Type I interferon receptor polypeptide agonist, hyperglycosylated polypeptide variant, protease-resistant polypeptide variant, or hyperglycosylated, protease-resistant polypeptide variant in a first unit form. In these embodiments, the parent protein therapeutic is one that is typically administered at a second dose of the parent protein in a parenteral pharmaceutical composition, where the parenteral pharmaceutical composition is an immediate release formulation, e.g., an immediate release formulation suitable for bolus injection of the second dose at a selected dosing frequency. The parent protein therapeutic must be proven to be effective in the treatment of the disease in a patient when administered to the patient by subcutaneous bolus injection in an amount of the parenteral pharmaceutical composition whereby the patient receives the second dose of the parent protein therapeutic at the selected dosing frequency. When the first dose of the known synthetic Type I interferon receptor polypeptide agonist, hyperglycosylated polypeptide variant, protease-resistant polypeptide variant, or hyperglycosylated, protease-resistant polypeptide variant is administered orally to the patient, the time required for release of all of the known synthetic Type I interferon receptor polypeptide agonist, hyperglycosylated polypeptide variant, protease-resistant polypeptide variant, or hyperglycosylated, protease-resistant polypeptide variant in the first dose is no greater than the time between doses in the selected dosing interval. The amount of the known synthetic Type I interferon receptor polypeptide agonist, hyperglycosylated polypeptide variant, protease-resistant polypeptide variant, or hyperglycosylated, protease-resistant polypeptide variant in moles of drug per kilogram of patient body weight in the first dose is greater than the amount of parent protein therapeutic in moles of drug per kilogram of patient body weight in the second dose when the first and second doses are calculated for the average patient body weight in the total population of patients suffering from the disease.

[00604] In some embodiments, the second dose is a weight-based dose, and the first dose is greater in moles of drug than the product of the second dose in moles of drug per kilogram of patient body weight multiplied by an average patient's body weight (e.g. 75 kilograms).

[00605] In other embodiments, the second dose is stratified by patient body weight, i.e., the second dose is selected from a set of two or more doses stratified by patient body weight (e.g., 1,000 mg of drug for patients having a body weight  $\leq 75$  kg and 1,200 mg of drug for patients having a body weight  $> 75$  kg), and the first dose is greater in moles of drug than the largest dose of the set of patient body weight-stratified doses.

[00606] In still other embodiments, the second dose is a fixed dose, and the first dose is greater than the second dose in moles of drug.

[00607] In one non-limiting example, the invention provides any of the oral pharmaceutical compositions used to administer orally a known synthetic IFN- $\alpha$  receptor polypeptide agonist, hyperglycosylated polypeptide variant, protease-resistant polypeptide variant, or hyperglycosylated, protease-resistant polypeptide variant in a method of treatment described in "Treatment Methods Using IFN- $\alpha$ " below.

[00608] In another non-limiting example, the invention provides any of the oral pharmaceutical compositions used to administer orally a known a subject synthetic IFN- $\beta$  receptor polypeptide agonist, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant in a method of treatment described in "Treatment Methods Using IFN- $\beta$ " below.

[00609] In another non-limiting example, the invention provides any of the oral pharmaceutical compositions used to administer orally a known synthetic IFN- $\gamma$  receptor polypeptide agonist, hyperglycosylated polypeptide variant, protease-resistant polypeptide variant, or hyperglycosylated, protease-resistant polypeptide variant in a method of treatment described in "Treatment Methods Using IFN- $\gamma$ " below.

Oral formulations with a peptide carrier

[00610] Additional oral formulations suitable for use herein include a known subject synthetic Type I interferon receptor polypeptide variant, a known hyperglycosylated polypeptide variant, a known protease-resistant polypeptide variant, or a known hyperglycosylated, protease-resistant polypeptide variant formulated with a carrier for oral delivery as described in WO 03/066859. For example, a suitable oral formulation includes a desired synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant; and a penetrating peptide (also referred to as a "peptide carrier"). A penetrating peptide is any

peptide that facilitates translocation of a substance across a biological barrier, e.g., the epithelial layer lining the gastrointestinal tract. Suitable peptide carriers include those derived from various proteins including, but not limited to, an integral membrane protein, a bacterial toxin, a non-pathogenic bacterium, a viral protein, an extracellular protein, and the like. The amino acid sequence of the peptide carrier can be the same as the amino acid sequence of a naturally-occurring peptide, or may be an altered version of such a peptide (e.g., including one or more amino acid substitutions compared to a naturally-occurring peptide).

[00611] Peptide carriers are typically from about 10 amino acids to about 30 amino acids in length, e.g., from about 10 amino acids to about 15 amino acids, from about 15 amino acids to about 20 amino acids, from about 20 amino acids to about 25 amino acids, or from about 25 amino acids to about 30 amino acids in length.

[00612] Suitable peptide carriers include, but are not limited to, any one of peptides 1-34, as shown in Table 9, below (SEQ ID NOs:1311-1326).

Table 9

Peptide/Organism	Sequence
Peptide 1: from ORF HI0638 <i>Haemophilus influenzae</i>	NYHDIVLALAGVCQSAKL VHQLA
Peptide 2: from PM1850 <i>Pasteurella multocida</i>	NYDITLALAGVCQAAKL VQQFA
Peptide 3: from YCFC <i>Escherichia coli</i>	NYDITLALAGICQSARLVQQLA
Peptide 4: from VC1127 <i>Vibrio cholerae</i>	AIYDRTIAFAGICQAVALVQQVA
Peptide 5: from BU262 <i>Buchnera aphidicola</i>	KIHLITLSLAGICQSAHLVQQLA
Peptide 6: from PA2627 <i>Pseudomonas aeruginosa</i>	DPRQQLIALGAVFESAALVDKLA
Peptide 7: from XF1439 <i>Xylella fastidiosa</i>	LIDNRVLALAGVVQALQQVRQIA
Peptide 8: from MLR0187 <i>Rhizobium loti</i>	NLPPIVLA VIGICAAVFL LQQYV
Peptide 9: from Human NK-2 Receptor	NYFIVNLALADLCMAAFNAAFNE
Peptide 10: from CPN0710/C <i>Chlamydia pneumoniae</i>	TAFDFNKMLDGVCTVVKGVQQYL
Peptide 11: from MLR4119 <i>Rhizobium loti</i>	RAILPLALAGLCQVARAGDISS
Peptide 12: from NprB <i>Bacillus subtilis</i>	MRNLTKTSL LLAGLCTAAQMVFVTH
Peptide 13: from Pilin <i>Kingella dantricans</i>	IELMIVIAIGILAAIALPAYQEVV
Peptide 14: from Pilin <i>Elkenella corrodens</i>	IELMIVIAIGILAAIALPAYQDYV
Peptide 15: from zonula occludens toxin (ZOT)	ASFGFCIGRLCVQDGF
Peptide 29: from Human NK-1 Receptor	NYFLVNLAFAEASMAAFNTVVNF



Peptide 30: from YCFC <i>Escherichia coli</i>	MNYYDITLALAGICQSARLVQQLA
Peptide 31: from YCFC <i>Escherichia coli</i>	MYDITLALAGICQSARLVQQLA
Peptide 32: from YCFC <i>Escherichia coli</i>	MYDITLALAGICQSARLVQQLA
Peptide 33: from NprB <i>Bacillus subtilis</i>	MRNLTRTSLIAGLCTAAQMVFV
Peptide 34: from ORF HI0638 <i>Haemophilus influenzae</i>	NYHDIVLALAGVCQSARLVHQLA

[00613] Suitable peptide carriers also include variants of any one of peptides 1-34 as shown in Table 9, e.g., a variant which differs from any one of peptides 1-34 by from about one amino acid to about 5 amino acids; and fragments of any one of peptides 1-34. Variants of any one of peptides 1-34 include those having from about one to about five conservative amino acid substitutions, and/or non-conservative amino acid substitutions compared to the amino acid sequence of any one of peptides 1-34. Fragments of any one of peptides 1-34 include fragments containing from about 10 contiguous amino acids to about 15 contiguous amino acids, fragments containing from about 15 contiguous amino acids to about 20 contiguous amino acids, and fragments containing from about 20 contiguous amino acids to about 25 contiguous amino acids, of any one of peptides 1-34.

[00614] The peptide carrier may be "associated with" (also referred to as "fused to," "coupled to," "linked to," or "attached to") a desired synthetic Type I interferon receptor, a hyperglycosylated, a protease-resistant, or a hyperglycosylated, protease-resistant protein in any of a number of ways, including, e.g., via a covalent interaction, an ionic interaction, a hydrophobic interaction, a hydrogen bond, or other type of association (e.g., van der Waal interaction; a non-specific association due to solvent preference; and the like). Attachment of a peptide carrier to a desired protein is achieved by any chemical, biochemical, enzymatic, or genetic coupling method known to those skilled in the art.

[00615] If the peptide carrier is coupled to the desired synthetic Type I interferon receptor, a hyperglycosylated, a protease-resistant, or a hyperglycosylated, protease-resistant protein, typically the N-terminus of the desired protein is coupled to the carboxyl terminus of the peptide carrier. A desired synthetic Type I interferon receptor, a hyperglycosylated, a protease-resistant, or a hyperglycosylated, protease-resistant protein may be coupled to the peptide carrier directly or indirectly via a covalent bond. For example, the covalent bond may be a peptide bond; or the covalent bond may be achieved by a homo- or a hetero-functional bridging reagent. The bridging reagent may be a succinimidyl-(N-maleimidomethyl)cyclohexane-1-carboxylate (SMCC)-type carrier. The covalent bond may be achieved using a peptide linker.

[00616] In some embodiments, a desired synthetic Type I interferon receptor, a hyperglycosylated, a protease-resistant, or a hyperglycosylated, protease-resistant protein is coupled to the peptide carrier via a linker peptide, which may be cleavable. The linker peptide may have any of a variety of amino acid sequences. Proteins can be joined by a spacer peptide, generally of a flexible nature, although other chemical linkages are not excluded. Currently, it is contemplated that the most useful linker sequences will generally be peptides of between about 6 and about 40 amino acids in length, or between about 6 and about 25 amino acids in length. These linkers are generally produced by using synthetic, linker-encoding oligonucleotides to couple the proteins. Peptide linkers with a degree of flexibility will generally be preferred. The linking peptides may have virtually any amino acid sequence, bearing in mind that the preferred linkers will have a sequence that results in a generally flexible peptide. The use of small amino acids, such as glycine and alanine, are of use in creating a flexible peptide. The creation of such sequences is routine to those of skill in the art. A variety of different linkers are commercially available and are considered suitable for use according to the present invention.

[00617] Amino acid sequences rich in alanine and proline residues are known to impart flexibility to multi-domain protein structures. For example, such sequences link the domains of the so-called E2 components of the 2-oxo acid dehydrogenase complexes, such as pyruvate dehydrogenase complex and 2-oxo glutarate dehydrogenase complex. Alanine-proline rich regions are also found in myosin light chains. Exemplary linkers for use in the invention have a combination of glycine, alanine, proline and methionine residues, such as AAAGGM (SEQ ID NO:1332); AAAGGMPPAAAGGM (SEQ ID NO:1333); AAAGGM (SEQ ID NO:1334); and PPAAAGGM<sub>2</sub> (SEQ ID NO:1335). Other exemplary linker peptides include IEGR (SEQ ID NO:1336; which can be cleaved by factor Xa) and GGKGGK (SEQ ID NO:1337). However, any flexible linker generally between about 6 and about 40 amino acids in length may be used. Linkers may have virtually any sequence that results in a generally flexible peptide, including alanine-proline rich sequences of the type exemplified above.

[00618] In some embodiments, a desired synthetic Type I interferon receptor, a hyperglycosylated, a protease-resistant, or a hyperglycosylated, protease-resistant protein is coupled to the peptide carrier via a linker peptide that is cleavable by an enzyme. In some embodiments, the enzyme is conditionally activated under a particular physiological condition.

[00619] In other embodiments, a desired synthetic Type I interferon receptor, a hyperglycosylated, a protease-resistant, or a hyperglycosylated, protease-resistant protein is coupled to the peptide carrier via a non-covalent bond, where the non-covalent bond is

achieved by an attachment of a hydrophobic moiety to the peptide carrier, such that the hydrophobic moiety enables the peptide carrier to be incorporated at the interface of a hydrophobic vesicle in which a desired synthetic Type I interferon receptor, a hyperglycosylated, a protease-resistant, or a hyperglycosylated, protease-resistant polypeptide is contained. In other embodiments, the non-covalent bond is a non-covalent, high affinity bond, such as a biotin-avidin or a biotin-streptavidin bond.

[00620] Peptides may be synthesized chemically or enzymatically, may be produced recombinantly, may be isolated from a natural source, or a combination of the foregoing. Peptides may be isolated from natural sources using standard methods of protein purification known in the art, including, but not limited to, high-performance liquid chromatography, exclusion chromatography, gel electrophoresis, affinity chromatography, or other purification technique. One may employ solid phase peptide synthesis techniques, where such techniques are known to those of skill in the art. *See Jones, The Chemical Synthesis of Peptides (Clarendon Press, Oxford)(1994).* Generally, in such methods a peptide is produced through the sequential additional of activated monomeric units to a solid phase bound growing peptide chain. Well-established recombinant DNA techniques can be employed for production of peptides.

[00621] Exemplary oral formulations include enteric coated tablets and gelatin capsules that include a peptide carrier; a desired synthetic Type I interferon receptor, a hyperglycosylated, a protease-resistant, or a hyperglycosylated, protease-resistant protein; and one or more of: a) a diluent, e.g., lactose, dextrose, sucrose, mannitol, sorbitol, cellulose and/or glycine; b) a protease inhibitor such as Aprotinin or trasylol; c) a lubricant, e.g., silica, talcum, stearic acid, its magnesium and/or calcium salt, poloxamer or polyethylene glycol; d) a binder (e.g., for tablets), e.g., magnesium aluminum silicate, starch paste, gelatin, tragacanth, methylcellulose, sodium carboxymethylcellulose and/or polyvinylpyrrolidone; e) an ionic surfactant active agent such as bile salts; f) a disintegrant, e.g., starches, agar, alginic acid or its sodium salt, or effervescent mixtures; and g) one or more of an absorbent, a colorant, a flavoring agent, and a sweetener. In some embodiments the oral formulation further comprises one or more of a preserving agent, a stabilizing agent, a wetting agent, an emulsifying agent, a solution promoter, a salt, and a buffer.

[00622] The oral formulations will in some embodiments further include one or more of a non-ionic detergent, an ionic detergent, a protease inhibitor, and a reducing agent. The non-ionic detergent may be a poloxamer such as Pluronic F-68; the ionic detergent may be a bile salt

such as taurodeoxycholate; the protease inhibitor may be aprotinin or soy bean trypsin inhibitor; and the reducing agent may be N-acetyl-L-cysteine.

Combination formulations

- [00623] The present invention provides a pharmaceutical composition comprising a subject synthetic Type I interferon receptor polypeptide agonist that is glycosylated; a glycosylated IFN- $\gamma$ ; and a pharmaceutically acceptable excipient. In some embodiments, the subject glycosylated synthetic Type I interferon receptor polypeptide agonist and the glycosylated IFN- $\gamma$  are co-formulated. In some embodiments, the subject glycosylated synthetic Type I interferon receptor polypeptide agonist and the glycosylated IFN- $\gamma$  are co-formulated in a single liquid formulation that is contained in a single reservoir, for use in a drug delivery device. In some embodiments, the subject glycosylated synthetic Type I interferon receptor polypeptide agonist and the glycosylated IFN- $\gamma$  are in a formulation suitable for delivery by injection. In other embodiments, the subject glycosylated synthetic Type I interferon receptor polypeptide agonist and the glycosylated IFN- $\gamma$  are in a formulation suitable for oral delivery. Formulations suitable for oral delivery include those discussed above.
- [00624] The present invention provides a pharmaceutical formulation comprising a single dose of a subject glycosylated synthetic Type I interferon receptor polypeptide agonist and a single dose of a glycosylated IFN- $\gamma$  sufficient for use in any method described herein that employs the co-administration of a subject glycosylated synthetic Type I interferon receptor polypeptide agonist and a glycosylated IFN- $\gamma$  in the treatment of a patient. In some aspects, the present invention provides a drug reservoir or other container containing a subject glycosylated synthetic Type I interferon receptor polypeptide agonist and a glycosylated IFN- $\gamma$  co-formulated in a liquid, wherein both subject glycosylated synthetic Type I interferon receptor polypeptide agonist and glycosylated IFN- $\gamma$  are present in the formulation in an amount suitable for one dose each. Dosage amounts are described herein. The reservoir can be provided in any of a variety of forms, including, but not limited to, a cartridge, a syringe, a reservoir of a continuous delivery device, and the like.
- [00625] In some embodiments, a pharmaceutical composition comprising a subject glycosylated synthetic Type I interferon receptor polypeptide agonist and a glycosylated IFN- $\gamma$  polypeptide is formed by admixture of (a) a pharmaceutical composition comprising the subject glycosylated synthetic Type I interferon receptor polypeptide agonist in a sterile water solution; and (b) a pharmaceutical composition comprising the glycosylated IFN- $\gamma$  in a sterile water solution.

**POLYNUCLEOTIDES, VECTORS, AND HOST CELLS**

- [00626] The present invention further provides a polynucleotide (“nucleic acid”) comprising a nucleotide sequence that encodes a subject synthetic Type I interferon receptor polypeptide agonist, vectors comprising a subject polynucleotide, and host cells comprising a subject polynucleotide or vector. A subject polynucleotide is useful for generating a subject expression vector and genetically modified host cells, which are useful for producing a subject polypeptide agonist.
- [00627] The subject invention provides nucleic acid compositions encoding a subject synthetic Type I interferon receptor polypeptide agonist. As used herein, the term “nucleic acid composition” refers to a composition comprising a sequence of a nucleic acid having an open reading frame that encodes a subject synthetic Type I interferon receptor polypeptide agonist, and is capable, under appropriate conditions, of being expressed such that a synthetic Type I interferon receptor polypeptide agonist is produced in a host cell comprising the nucleic acid. Also encompassed in this term are nucleic acids that are homologous or substantially similar or identical to the nucleic acids encoding a subject synthetic Type I interferon receptor polypeptide agonist.
- [00628] Thus, the subject invention provides nucleic acids comprising a nucleotide sequence encoding a subject synthetic Type I interferon receptor polypeptide agonist, and nucleic acids having substantial nucleotide sequence identity to such nucleic acids (e.g., homologs). In many embodiments, a subject nucleic acid comprises a nucleotide sequence that encodes a subject synthetic Type I interferon receptor polypeptide agonist and that has at least about 75%, at least about 80%, at least about 85%, at least about 90%, at least about 95%, at least about 98%, or at least about 99%, or more, nucleotide sequence identity with a nucleotide sequence (particularly the subject polypeptide-encoding region of the nucleotide sequence) encoding a subject synthetic Type I interferon receptor polypeptide agonist.
- [00629] In some embodiments, a subject nucleic acid comprises a nucleotide sequence encoding a synthetic Type I interferon receptor polypeptide agonist comprising an amino acid sequence as set forth in any one of SEQ ID NOs:9-19. In some embodiments, a subject nucleic acid comprises a nucleotide sequence as set forth in any one of SEQ ID NOs:24-34.
- [00630] In some embodiments, a subject nucleic acid comprises a nucleotide sequence encoding a synthetic Type I interferon receptor polypeptide agonist comprising an amino acid sequence as set forth in any one of SEQ ID NOs:48-52. In some embodiments, a subject nucleic acid comprises a nucleotide sequence encoding a synthetic Type I interferon receptor polypeptide agonist comprising an amino acid sequence as set forth in any one of SEQ ID NOs:55-59.

[00631] Sequence similarity is calculated based on a reference sequence, which may be a subset of a larger sequence, such as a conserved motif, coding region, flanking region, *etc.* A reference sequence will usually be at least about 18 nt long, more usually at least about 30 nt long, and may extend to the complete sequence that is being compared. Algorithms for sequence analysis are known in the art, such as BLAST, described in Altschul *et al.* (1990), *J. Mol. Biol.* 215:403-10 (using default settings, i.e. parameters  $w=4$  and  $T=17$ ).

[00632] Also provided are nucleic acids that hybridize to the above-described nucleic acids under stringent conditions. An example of stringent hybridization conditions is hybridization at 50°C or higher and 0.1×SSC (15 mM sodium chloride/1.5 mM sodium citrate). Another example of stringent hybridization conditions is overnight incubation at 42°C in a solution: 50% formamide, 5 × SSC (150 mM NaCl, 15 mM trisodium citrate), 50 mM sodium phosphate (pH 7.6), 5 × Denhardt's solution, 10% dextran sulfate, and 20 µg/ml denatured, sheared salmon sperm DNA, followed by washing the filters in 0.1 × SSC at about 65°C. Stringent hybridization conditions are hybridization conditions that are at least as stringent as the above representative conditions. Other stringent hybridization conditions are known in the art and may also be employed to identify nucleic acids of this particular embodiment of the invention.

[00633] Nucleic acids encoding the proteins and polypeptides of the subject invention are in many embodiments DNA, including cDNA. The term "synthetic Type I interferon receptor polypeptide agonist nucleic acid," as used herein, refers to the open reading frame encoding specific subject polypeptides, as well as adjacent 5' and 3' non-coding nucleotide sequences involved in the regulation of expression, e.g., from about 100 bp up to about 20 kb beyond the coding region, but possibly further in either direction. The nucleic acid may be introduced into an appropriate vector for extrachromosomal maintenance or for integration into a host genome, as described in greater detail below.

[00634] The nucleic acid compositions of the subject invention may encode all or a part of the subject synthetic Type I interferon receptor polypeptide agonists. Double or single stranded fragments may be obtained from the DNA sequence by chemically synthesizing oligonucleotides in accordance with conventional methods, by restriction enzyme digestion, by polymerase chain reaction (PCR) amplification, *etc.*

[00635] In some embodiments, a subject nucleic acid is prepared by chemical synthesis, e.g. by using an oligonucleotide synthesizer, wherein oligonucleotides are designed based on the amino acid sequence of the desired polypeptide, and in many embodiments, selecting those codons that are favored in the host cell in which the recombinant polypeptide will be produced. For example, several small oligonucleotides coding for portions of the desired polypeptide may

be synthesized and assembled by PCR, ligation or ligation chain reaction (LCR). The individual oligonucleotides typically contain 5' or 3' overhangs for complementary assembly. Once assembled, the nucleotide sequence encoding the subject polypeptide is inserted into a recombinant vector and operably linked to control sequences necessary for expression of the subject nucleic acid, and subsequent production of the subject polypeptide, in the desired transformed host cell.

[00636] In some embodiments, a subject nucleic acid is generated such that at least about 10%, at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, or at least about 90%, or more, of the codons are codons that are preferred in human sequences. See, e.g., Table 8, below.

[00637] The subject nucleic acid molecules are generally propagated by placing the molecule in a vector. Viral and non-viral vectors are used, including plasmids. The choice of plasmid will depend on the type of cell in which propagation is desired and the purpose of propagation. Certain vectors are useful for amplifying and making large amounts of the desired DNA sequence.

[00638] The present invention further provides recombinant vectors ("constructs") comprising a subject polynucleotide. Recombinant vectors include vectors used for propagation of a polynucleotide of the invention, and expression vectors. Recombinant vectors are useful for propagation of the subject polynucleotides (cloning vectors). A subject recombinant expression vector is useful for effecting expression of a subject polynucleotide in a cell, e.g., for production of a subject synthetic Type I interferon receptor polypeptide agonist. The choice of appropriate vector is well within the skill of the art. Many such vectors are available commercially.

[00639] Expression vectors are suitable for expression in cells in culture. These vectors will generally include regulatory sequences ("control sequences" or "control regions") which are necessary to effect the expression of a subject polynucleotide to which they are operably linked. Still other vectors are suitable for transfer and expression in cells in a whole organism or person.

[00640] Expression vectors generally have convenient restriction sites located near the promoter sequence to provide for the insertion of nucleic acid sequences encoding heterologous proteins. A selectable marker operative in the expression host may be present. Expression vectors may be used for the production of fusion proteins, where the exogenous fusion peptide provides additional functionality, i.e. increased protein synthesis, stability, reactivity with defined antisera, an enzyme marker, e.g.  $\beta$ -galactosidase, luciferase, etc.

[00641] Expression cassettes may be prepared that comprise a transcription initiation region, a promoter region (e.g., a promoter that is functional in a eukaryotic cell), a subject polynucleotide, and a transcriptional termination region. After introduction of the DNA, the cells containing the construct may be selected by means of a selectable marker, the cells expanded and then used for expression.

[00642] The expression cassettes may be introduced into a variety of vectors, *e.g.* plasmid, BAC, HAC, YAC, bacteriophage such as lambda, P1, M13, *etc.*, animal or plant viruses, and the like, where the vectors are normally characterized by the ability to provide selection of cells comprising the expression vectors. The vectors may provide for extrachromosomal maintenance, particularly as plasmids or viruses, or for integration into the host chromosome. Where extrachromosomal maintenance is desired, an origin sequence is provided for the replication of the plasmid, which may be low- or high copy-number. A wide variety of markers are available for selection, particularly those that protect against toxins, more particularly against antibiotics. The particular marker that is chosen is selected in accordance with the nature of the host, where in some cases, complementation may be employed with auxotrophic hosts. Introduction of the DNA construct into a host cell may use any convenient method, *e.g.* conjugation, bacterial transformation, calcium-precipitated DNA, electroporation, fusion, transfection, infection with viral vectors, biolistics, *etc.*

[00643] General aspects of mammalian cell host system transformations have been described by Axel in U.S. Pat. No. 4,399,216 issued Aug. 16, 1983. Transformations into yeast are typically carried out according to the method of Van Solingen et al., *J. Bact.*, 130: 946 (1977) and Hsiao et al., *Proc. Natl. Acad. Sci. (USA)*, 76: 3829 (1979). Optimized methods for calcium phosphate transfection of eukaryotic host cells are described by Wurm and Jordan in U.S. Pat. Nos. 5,484,720 and 5,593,875. However, other methods for introducing DNA into cells such as by nuclear injection, electroporation, or by protoplast fusion may also be used.

[00644] The present invention further provides genetically modified host cells, which may be isolated host cells, comprising a subject polynucleotide, or, in some embodiments, a subject expression vector. Suitable host cells include prokaryotes such as *E. coli*, *B. subtilis*; eukaryotes, including insect cells in combination with baculovirus vectors, yeast cells, such as *Saccharomyces cerevisiae*, or cells of a higher organism such as vertebrates, including amphibians (e.g., *Xenopus laevis* oocytes), and mammals, particularly mammals, e.g. COS cells, CHO cells, HEK293 cells, MA-10 cells, and the like, may be used as the expression host cells. Host cells can be used for the purposes of propagating a subject polynucleotide, for production of a subject synthetic Type I interferon receptor polypeptide agonist. In many



embodiments, the host cell is a eukaryotic host cell. In particular, the host cell is in many embodiments a eukaryotic host cell that is capable of glycosylating a protein.

[00645] The mammalian host cells used to produce a subject synthetic Type I interferon receptor polypeptide agonist can be cultured in a variety of media. Commercially available media such as Ham's F10 (Sigma), Minimal Essential Medium ((MEM), Sigma), RPMI-1640 (Sigma), and Dulbecco's Modified Eagle's Medium ((DMEM), Sigma) are suitable for culturing the host cells. In addition, any of the media described in Ham and Wallace, *Meth. Enz.*, 58: 44 (1979), Barnes and Sato, *Anal Biochem.*, 102: 255 (1980), U.S. Pat. Nos. 4,767,704; 4,657,866; 4,927,762; or U.S. Pat. No. 4,560,655; WO 90/03430; WO 87/00195; U.S. Pat. Re. No. 30,985; or U.S. Pat. No. 5,122,469, the disclosures of all of which are incorporated herein by reference, may be used as culture media for the host cells. Any of these media may be supplemented as necessary with hormones and/or other growth factors (such as insulin, transferrin, or epidermal growth factor), salts (such as sodium chloride, calcium, magnesium, and phosphate), buffers (such as HEPES), nucleosides (such as adenosine and thymidine), antibiotics (such as Gentamycin™ drug), trace elements (defined as inorganic compounds usually present at final concentrations in the micromolar range), and glucose or an equivalent energy source. Any other necessary supplements may also be included at appropriate concentrations that would be known to those skilled in the art. The culture conditions, such as temperature, pH, and the like, are those previously used with the host cell selected for expression, and will be apparent to the ordinarily skilled artisan.

#### ANTIBODY COMPOSITIONS

[00646] Also provided are antibodies that bind specifically a subject synthetic Type I interferon receptor polypeptide agonist. Suitable antibodies are obtained by immunizing a host animal with peptides comprising all or a portion of the subject protein. Suitable host animals include mouse, rat sheep, goat, hamster, rabbit, *etc.* In many embodiments, a subject antibody is isolated; and in many embodiments a subject antibody is purified.

[00647] The immunogen may comprise the complete protein, or fragments and derivatives thereof. Exemplary immunogens comprise all or a part of the protein, where these residues contain the post-translation modifications found on the native target protein. Immunogens are produced in a variety of ways known in the art, *e.g.*, expression of cloned genes using conventional recombinant methods, chemical synthesis of synthetic Type I interferon receptor polypeptide agonist polypeptides, *etc.*

[00648] For preparation of polyclonal antibodies, the first step is immunization of the host animal with the target protein, where the target protein will preferably be in substantially pure

form, comprising less than about 1% contaminant. The immunogen may comprise the complete target protein, fragments or derivatives thereof. To increase the immune response of the host animal, the target protein may be combined with an adjuvant, where suitable adjuvants include alum, dextran, sulfate, large polymeric anions, oil and water emulsions, e.g. Freund's adjuvant, Freund's complete adjuvant, and the like. The target protein may also be conjugated to synthetic carrier proteins or synthetic antigens. A variety of hosts may be immunized to produce the polyclonal antibodies. Such hosts include rabbits, guinea pigs, rodents, e.g. mice, rats, sheep, goats, and the like. The target protein is administered to the host, usually intradermally, with an initial dosage followed by one or more, usually at least two, additional booster dosages. Following immunization, the blood from the host will be collected, followed by separation of the serum from the blood cells. The Ig present in the resultant antiserum may be further fractionated using known methods, such as ammonium salt fractionation, DEAE chromatography, and the like.

[00649] Monoclonal antibodies are produced by conventional techniques. Generally, the spleen and/or lymph nodes of an immunized host animal provide a source of plasma cells. The plasma cells are immortalized by fusion with myeloma cells to produce hybridoma cells. Culture supernatant from individual hybridomas is screened using standard techniques to identify those producing antibodies with the desired specificity. Suitable animals for production of monoclonal antibodies to the human protein include mouse, rat, hamster, *etc.* To raise antibodies against the mouse protein, the animal will generally be a hamster, guinea pig, rabbit, *etc.* The antibody may be purified from the hybridoma cell supernatants or ascites fluid by conventional techniques, *e.g.* affinity chromatography using protein bound to an insoluble support, protein A sepharose, *etc.*

[00650] The antibody may be produced as a single chain, instead of the normal multimeric structure. Single chain antibodies are described in Jost *et al.* (1994) *J. Biol. Chem.* 269:26267-73, and others. DNA sequences encoding the variable region of the heavy chain and the variable region of the light chain are ligated to a spacer encoding at least about 4 amino acids of small neutral amino acids, including glycine and/or serine. The protein encoded by this fusion allows assembly of a functional variable region that retains the specificity and affinity of the original antibody.

[00651] Also of interest in certain embodiments are humanized antibodies. Methods of humanizing antibodies are known in the art. The humanized antibody may be the product of an animal having transgenic human immunoglobulin constant region genes (see for example International Patent Applications WO 90/10077 and WO 90/04036). Alternatively, the

antibody of interest may be engineered by recombinant DNA techniques to substitute the CH1, CH2, CH3, hinge domains, and/or the framework domain with the corresponding human sequence (see WO 92/02190).

- [00652] The use of Ig cDNA for construction of chimeric immunoglobulin genes is known in the art (Liu *et al.* (1987) *Proc. Natl. Acad. Sci. USA* 84:3439 and (1987) *J. Immunol.* 139:3521). mRNA is isolated from a hybridoma or other cell producing the antibody and used to produce cDNA. The cDNA of interest may be amplified by the polymerase chain reaction using specific primers (U.S. Patent nos. 4,683,195 and 4,683,202). Alternatively, a library is made and screened to isolate the sequence of interest. The DNA sequence encoding the variable region of the antibody is then fused to human constant region sequences. The sequences of human constant regions genes may be found in Kabat *et al.* (1991) Sequences of Proteins of Immunological Interest, N.I.H. publication no. 91-3242. Human C region genes are readily available from known clones. The choice of isotype will be guided by the desired effector functions, such as complement fixation, or activity in antibody-dependent cellular cytotoxicity. Exemplary isotypes are IgG1, IgG3 and IgG4. Either of the human light chain constant regions, kappa or lambda, may be used. The chimeric, humanized antibody is then expressed by conventional methods.
- [00653] Antibody fragments, such as Fv, F(ab')<sub>2</sub> and Fab may be prepared by cleavage of the intact protein, *e.g.* by protease or chemical cleavage. Alternatively, a truncated gene is designed. For example, a chimeric gene encoding a portion of the F(ab')<sub>2</sub> fragment would include DNA sequences encoding the CH1 domain and hinge region of the H chain, followed by a translational stop codon to yield the truncated molecule.
- [00654] Consensus sequences of H and L J regions may be used to design oligonucleotides for use as primers to introduce useful restriction sites into the J region for subsequent linkage of V region segments to human C region segments. C region cDNA can be modified by site directed mutagenesis to place a restriction site at the analogous position in the human sequence.
- [00655] Expression vectors include plasmids, retroviruses, YACs, EBV derived episomes, and the like. A convenient vector is one that encodes a functionally complete human CH or CL immunoglobulin sequence, with appropriate restriction sites engineered so that any VH or VL sequence can be easily inserted and expressed. In such vectors, splicing usually occurs between the splice donor site in the inserted J region and the splice acceptor site preceding the human C region, and also at the splice regions that occur within the human CH exons. Polyadenylation and transcription termination occur at native chromosomal sites downstream

of the coding regions. The resulting chimeric antibody may be joined to any strong promoter, including retroviral LTRs, *e.g.* SV-40 early promoter, (Okayama *et al.* (1983) *Mol. Cell. Bio.* 3:280), Rous sarcoma virus LTR (Gorman *et al.* (1982) *Proc. Natl. Acad. Sci. USA* 79:6777), and moloney murine leukemia virus LTR (Grosschedl *et al.* (1985) *Cell* 41:885); native Ig promoters, *etc.*

#### DIAGNOSTIC USES

[00656] The synthetic Type I interferon receptor polypeptide agonists of the invention are unique research reagents which provide Type I interferon activity templates for use in chemical library screening, wherein the practitioner can use a signal transduction assay as an initial, high volume screen for agents that inhibit a broad array of Type I interferon activities similar to the Type I interferon activity pattern of a subject synthetic Type I interferon receptor polypeptide agonist. In this way, candidate agents likely to inhibit a broad spectrum of Type I interferon activities (similar to the activity profile of a subject synthetic Type I interferon receptor polypeptide agonist) can be obtained with ease, avoiding prohibitively expensive and logistically impossible numbers of viral growth inhibition assays or cell proliferation inhibition assays on large chemical libraries.

[00657] In one embodiment, the synthetic Type I interferon receptor polypeptide agonists of the invention are used to screen chemical libraries in a Kinase Receptor Activation (KIRA) Assay as described in WO 95/14930 (published 1 June 1995). The KIRA assay is suitable for use herein because ligand binding to the Type I interferon receptor complex in situ on the surface of host cells expressing the receptor induces a rapid increase in the phosphorylation of tyrosine residues in the intracellular domains of both IFNAR1 and IFNAR2 components of the receptor as taught in Plataniotis and Colamonici, *J. Biol. Chem.*, 269: 17761-17764 (1994). The level of tyrosine phosphorylation can be used as a measure of signal transduction. The effect of a library compound on the levels of tyrosine phosphorylation induced by a subject synthetic Type I interferon receptor polypeptide agonist in the KIRA assay is an indication of the compound's inhibitory activity against the broad array of Type I interferons mimicked by the subject synthetic Type I interferon receptor polypeptide agonist.

[00658] The KIRA assay suitable for use herein employs (a) a host cell that expresses the Type I interferon receptor (both IFNAR1 and IFNAR2 components of the receptor) and (b) the subject synthetic Type I interferon receptor polypeptide agonist, which defines the inhibitor profile of interest. Cells which naturally express the human Type I interferon receptor, such as the human Daudi cells and U-266 human myeloma cells described in Colamonici and Domanski, *J. Biol. Chem.* 268: 10895-10899 (1993), can be used. In addition, cells which are

transfected with the IFNAR1 and IFNAR2 components and contain intracellular signaling proteins necessary for Type I interferon signal transduction, such as mouse L-929 cells as described in Domanski et al., J. Biol. Chem., 270: 21606-21611 (1995), can be used. In the KIRA assay, the candidate antagonist is incubated with the subject synthetic Type I interferon receptor polypeptide agonist to be tested, and the incubation mixture is contacted with the Type I interferon receptor-expressing host cells. The treated cells are lysed, and IFNAR2 protein in the cell lysate is immobilized by capture with solid phase anti-IFNAR2 antibody. Signal transduction is assayed by measuring the amount of tyrosine phosphorylation that exists in the intracellular domain (ICD) of captured IFNAR2 and the amount of tyrosine phosphorylation that exists in the intracellular domain of any co-captured IFNAR1. Alternatively, cell lysis and immunoprecipitation can be performed under denaturing conditions in order to avoid co-capture of IFNAR1 and permit measurement of IFNAR2 tyrosine phosphorylation alone, e.g. as described in Platanias et al., J. Biol. Chem., 271: 23630-23633 (1996). The level of tyrosine phosphorylation can be accurately measured with labeled anti-phosphotyrosine antibody, which identifies phosphorylated tyrosine residues.

[00659] In another embodiment, a host cell coexpressing IFNAR1 and a chimeric construct containing IFNAR2 fused at its carboxy terminus to an affinity handle polypeptide is used in the KIRA assay. The chimeric IFNAR2 construct permits capture of the construct from cell lysate by use of a solid phase capture agent (in place of an anti-IFNAR2 antibody) specific for the affinity handle polypeptide. In a preferred embodiment, the affinity handle polypeptide is Herpes simplex virus glycoprotein D (gD) and the capture agent is an anti-gD monoclonal antibody as described in Examples 2 and 3 of WO 95/14930.

[00660] In this system, the synthetic Type I interferon receptor polypeptide agonist of the invention that possesses the Type I interferon activity profile of interest is used as a standard for analysis of the tyrosine phosphorylation inhibition patterns generated by the members of the chemical library that is screened. The IFNAR2 ICD tyrosine phosphorylation pattern generated by the synthetic Type I interferon receptor polypeptide agonist standard is compared to the tyrosine phosphorylation patterns produced by the standard in the presence of library compounds, and patterns found to indicate inhibition of tyrosine phosphorylation identify candidate agents that are likely to inhibit a range of type I interferon activities similar to the spectrum of Type I interferon activities mimicked by the standard. Accordingly, the synthetic Type I interferon receptor polypeptide agonist of the invention provides a useful means to quickly and efficiently screen large chemical libraries for compounds likely to inhibit the

particular spectrum of Type I interferon activities exhibited by the subject synthetic Type I interferon receptor polypeptide agonist.

[00661] In addition, the synthetic Type I interferon receptor polypeptide agonist of the invention are useful in diagnostic assays for Type I interferon receptor expression in specific cells or tissues. In these assays, the subject synthetic Type I interferon receptor polypeptide agonists are labeled as described below and/or immobilized on an insoluble matrix, which allows for the detection of Type I interferon receptor in a sample.

[00662] The subject synthetic Type I interferon receptor polypeptide agonists can be used for the detection of Type I interferon receptor in any one of a number of well known diagnostic assay methods. For example, a biological sample may be assayed for Type I interferon receptor by obtaining the sample from a desired source, admixing the sample with a subject synthetic Type I interferon receptor polypeptide agonist to allow the subject synthetic Type I interferon receptor polypeptide agonist to form agonist/Type I interferon receptor complex with any Type I interferon receptor present in the mixture, and detecting any agonist/Type I interferon receptor complex present in the mixture. The biological sample may be prepared for assay by methods known in the art that are suitable for the particular sample. The methods of admixing the sample with the subject synthetic Type I interferon receptor polypeptide agonist and the methods of detecting agonist/Type I interferon receptor complex are chosen according to the type of assay used. Such assays include competitive and sandwich assays, and steric inhibition assays. Competitive and sandwich methods employ a phase-separation step as an integral part of the method while steric inhibition assays are conducted in a single reaction mixture.

[00663] Analytical methods for Type I interferon receptor all use one or more of the following reagents: labeled Type I interferon receptor analogue, immobilized Type I interferon receptor analogue, labeled synthetic Type I interferon receptor polypeptide agonist, immobilized synthetic Type I interferon receptor polypeptide agonist and steric conjugates. The labeled reagents also are known as "tracers."

[00664] The label used is any detectable functionality that does not interfere with the binding of Type I interferon receptor and the subject synthetic Type I interferon receptor polypeptide agonist. Numerous labels are known for use in immunoassay, examples including moieties that may be detected directly, such as fluorochrome, chemiluminescent, and radioactive labels, as well as moieties, such as enzymes, that must be reacted or derivatized to be detected. Examples of such labels include the radioisotopes  $^{32}\text{P}$ ,  $^{14}\text{C}$ ,  $^{125}\text{I}$ ,  $^3\text{H}$ , and  $^{131}\text{I}$ , fluorophores such as rare earth chelates or fluorescein and its derivatives, rhodamine and its derivatives, dansyl, umbelliferone, luciferases, e.g., firefly luciferase and bacterial luciferase (U.S. Pat. No.

4,737,456), luciferin, 2,3-dihydrophthalazinediones, horseradish peroxidase (HRP), alkaline phosphatase,  $\beta$ -galactosidase, glucoamylase, lysozyme, saccharide oxidases, e.g., glucose oxidase, galactose oxidase, and glucose-6-phosphate dehydrogenase, heterocyclic oxidases such as uricase and xanthine oxidase, coupled with an enzyme that employs hydrogen peroxide to oxidize a dye precursor such as HRP, lactoperoxidase, or microperoxidase, biotin/avidin, spin labels, bacteriophage labels, stable free radicals, and the like.

[00665] Conventional methods are available to bind these labels covalently to proteins or polypeptides. For instance, coupling agents such as dialdehydes, carbodiimides, dimaleimides, bis-imidates, bis-diazotized benzidine, and the like may be used to tag the antibodies with the above-described fluorescent, chemiluminescent, and enzyme labels. See, for example, U.S. Pat. Nos. 3,940,475 (fluorimetry) and 3,645,090 (enzymes); Hunter et al., *Nature*, 144: 945 (1962); David et al., *Biochemistry*, 13: 1014-1021 (1974); Pain et al., *J. Immunol. Methods*, 40: 219-230 (1981); and Nygren, *J. Histochem. and Cytochem.*, 30: 407-412 (1982). Preferred labels herein are enzymes such as horseradish peroxidase and alkaline phosphatase.

[00666] The conjugation of such label, including the enzymes, to the antibody is a standard manipulative procedure for one of ordinary skill in immunoassay techniques. See, for example, O'Sullivan et al., "Methods for the Preparation of Enzyme-antibody Conjugates for Use in Enzyme Immunoassay," in *Methods in Enzymology*, ed. J. J. Langone and H. Van Vunakis, Vol. 73 (Academic Press, New York, N.Y., 1981), pp. 147-166.

[00667] Immobilization of reagents is required for certain assay methods. Immobilization entails separating the synthetic Type I interferon receptor polypeptide agonist from any Type I interferon receptor that remains free in solution. This conventionally is accomplished by either insolubilizing the synthetic Type I interferon receptor polypeptide agonist or Type I interferon receptor analogue before the assay procedure, as by adsorption to a water-insoluble matrix or surface (Bennich et al., U.S. Pat. No. 3,720,760), by covalent coupling (for example, using glutaraldehyde cross-linking), or by insolubilizing the synthetic Type I interferon receptor polypeptide agonist or Type I interferon receptor analogue afterward, e.g., by immunoprecipitation.

[00668] Other assay methods, known as competitive or sandwich assays, are well established and widely used in the commercial diagnostics industry.

[00669] Competitive assays rely on the ability of a tracer Type I interferon receptor analogue to compete with the test sample Type I interferon receptor for a limited number of synthetic Type I interferon receptor polypeptide agonist binding sites. The synthetic Type I interferon receptor polypeptide agonist generally is insolubilized before or after the competition and then the

tracer and Type I interferon receptor bound to the synthetic Type I interferon receptor polypeptide agonist are separated from the unbound tracer and Type I interferon receptor. This separation is accomplished by decanting (where the binding partner was preinsolubilized) or by centrifuging (where the binding partner was precipitated after the competitive reaction). The amount of test sample Type I interferon receptor is inversely proportional to the amount of bound tracer as measured by the amount of marker substance. Dose-response curves with known amounts of Type I interferon receptor are prepared and compared with the test results to quantitatively determine the amount of Type I interferon receptor present in the test sample. These assays are called ELISA systems when enzymes are used as the detectable markers.

[00670] Another species of competitive assay, called a "homogeneous" assay, does not require a phase separation. Here, a conjugate of an enzyme with the Type I interferon receptor is prepared and used such that when synthetic Type I interferon receptor polypeptide agonist binds to the Type I interferon receptor the presence of the synthetic Type I interferon receptor polypeptide agonist modifies the enzyme activity. In this case, the Type I interferon receptor or its immunologically active fragments are conjugated with a bifunctional organic bridge to an enzyme such as peroxidase. Conjugates are selected for use with synthetic Type I interferon receptor polypeptide agonist so that binding of the synthetic Type I interferon receptor polypeptide agonist inhibits or potentiates the enzyme activity of the label. This method per se is widely practiced under the name of EMIT.

[00671] Steric conjugates are used in steric hindrance methods for homogeneous assay. These conjugates are synthesized by covalently linking a low-molecular-weight hapten to a small Type I interferon receptor fragment so that antibody to hapten is substantially unable to bind the conjugate at the same time as synthetic Type I interferon receptor polypeptide agonist. Under this assay procedure the Type I interferon receptor present in the test sample will bind synthetic Type I interferon receptor polypeptide agonist, thereby allowing anti-hapten to bind the conjugate, resulting in a change in the character of the conjugate hapten, e.g., a change in fluorescence when the hapten is a fluorophore.

[00672] Sandwich assays particularly are useful for the determination of Type I interferon receptor in a sample. In sequential sandwich assays an immobilized synthetic Type I interferon receptor polypeptide agonist is used to adsorb test sample Type I interferon receptor, the test sample is removed as by washing, the bound Type I interferon receptor is used to adsorb a labeled anti-Type I interferon receptor antibody and bound material is then separated from residual tracer. The amount of bound tracer is directly proportional to test sample Type I



interferon receptor. In "simultaneous" sandwich assays the test sample is not separated before adding the labeled anti-Type I interferon receptor antibody.

- [00673] The foregoing are merely exemplary diagnostic assays for Type I interferon receptor. Other methods now or hereafter developed that use synthetic Type I interferon receptor polypeptide agonist for the determination of Type I interferon receptor are included within the scope hereof, including the bioassays described above.

#### **THERAPEUTIC METHODS**

- [00674] The present invention provides method of treating fibrotic disorders. The subject methods generally involve administering to an individual in need thereof an effective combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist. In some embodiments, a subject treatment method further includes administering at least one additional anti-fibrotic agent.
- [00675] The present invention further provides methods of treating cancer. The subject methods generally involve administering to an individual in need thereof an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant. In some embodiments, a subject method further includes administering at least one additional anti-cancer agent.
- [00676] The present invention additionally provides methods of treating viral infection. The subject methods generally involve administering to an individual in need thereof an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant. In some embodiments, a subject method further includes administering at least one additional anti-viral agent.
- [00677] In some embodiments, a subject treatment method further includes administering a side effect management agent, to treat a side effect induced by a therapeutic agent.

#### **FIBROTIC DISORDERS**

- [00678] The present invention provides methods for treating a fibrotic disorder in an individual having a fibrotic disorder. The method generally involves administering an effective combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor

agonist. The methods provide for treatment of fibrotic diseases, including those affecting the lung such as idiopathic pulmonary fibrosis, pulmonary fibrosis from a known etiology, liver fibrosis or cirrhosis, cardiac fibrosis, and renal fibrosis. The etiology may be due to any acute or chronic insult including toxic, metabolic, genetic and infectious agents.

[00679] Fibrosis is generally characterized by the pathologic or excessive accumulation of collagenous connective tissue. Fibrotic disorders include, but are not limited to, collagen disease, interstitial lung disease, human fibrotic lung disease (e.g., obliterative bronchiolitis, idiopathic pulmonary fibrosis, pulmonary fibrosis from a known etiology, tumor stroma in lung disease, systemic sclerosis affecting the lungs, Hermansky-Pudlak syndrome, coal worker's pneumoconiosis, asbestosis, silicosis, chronic pulmonary hypertension, AIDS-associated pulmonary hypertension, sarcoidosis, and the like), fibrotic vascular disease, arterial sclerosis, atherosclerosis, varicose veins, coronary infarcts, cerebral infarcts, myocardial fibrosis, musculoskeletal fibrosis, post-surgical adhesions, human kidney disease (e.g., nephritic syndrome, Alport's syndrome, HIV-associated nephropathy, polycystic kidney disease, Fabry's disease, diabetic nephropathy, chronic glomerulonephritis, nephritis associated with systemic lupus, and the like), cutis keloid formation, progressive systemic sclerosis (PSS), primary sclerosing cholangitis (PSC), liver fibrosis, liver cirrhosis, renal fibrosis, pulmonary fibrosis, cystic fibrosis, chronic graft versus host disease, scleroderma (local and systemic), Grave's ophthalmopathy, diabetic retinopathy, glaucoma, Peyronie's disease, penis fibrosis, urethrostenosis after the test using a cystoscope, inner accretion after surgery, scarring, myelofibrosis, idiopathic retroperitoneal fibrosis, peritoneal fibrosis from a known etiology, drug-induced ergotism, fibrosis incident to benign or malignant cancer, fibrosis incident to microbial infection (e.g., viral, bacterial, parasitic, fungal, etc.), Alzheimer's disease, fibrosis incident to inflammatory bowel disease (including stricture formation in Crohn's disease and microscopic colitis), fibrosis induced by chemical or environmental insult (e.g., cancer chemotherapy, pesticides, radiation (e.g., cancer radiotherapy), and the like), and the like.

[00680] In some embodiments, effective amounts of a synthetic Type I interferon receptor polypeptide agonist and a Type II interferon receptor agonist are any combined dosage that, when administered to an individual having a fibrotic disorder, is effective to reduce fibrosis or reduce the rate of progression of fibrosis by at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, or at least about 50%, or more, compared with the degree of fibrosis in the individual prior to treatment or compared to the rate of progression of fibrosis that would have been experienced by the patient in the absence of treatment.

[00681] In some embodiments, effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that, when administered to an individual having a fibrotic disorder, is effective to increase, or to reduce the rate of deterioration of, at least one function of the organ affected by fibrosis (e.g., lung, liver, kidney, etc.) by at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, or at least about 50%, or more, compared to the baseline level of organ function in the individual prior to treatment or compared to the rate of deterioration in organ function that would have been experienced by the individual in the absence of treatment.

[00682] Methods of measuring the extent of fibrosis in a given organ, and methods of measuring the function of any given organ, are well known in the art.

*Idiopathic Pulmonary Fibrosis*

[00683] The present invention provides methods of treating idiopathic pulmonary fibrosis (IPF). The methods generally involve administering to an individual having IPF effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist.

[00684] In some embodiments, a diagnosis of IPF is confirmed by the finding of usual interstitial pneumonia (UIP) on histopathological evaluation of lung tissue obtained by surgical biopsy. The criteria for a diagnosis of IPF are known. Ryu et al. (1998) *Mayo Clin. Proc.* 73:1085-1101.

[00685] In other embodiments, a diagnosis of IPF is a definite or probable IPF made by high resolution computer tomography (HRCT). In a diagnosis by HRCT, the presence of the following characteristics is noted: (1) presence of reticular abnormality and/or traction bronchiectasis with basal and peripheral predominance; (2) presence of honeycombing with basal and peripheral predominance; and (3) absence of atypical features such as micronodules, peribronchovascular nodules, consolidation, isolated (non-honeycomb) cysts, ground glass attenuation (or, if present, is less extensive than reticular opacity), and mediastinal adenopathy (or, if present, is not extensive enough to be visible on chest x-ray). A diagnosis of definite IPF is made if characteristics (1), (2), and (3) are met. A diagnosis of probable IPF is made if characteristics (1) and (3) are met.

[00686] In some embodiments, "effective amounts" of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are a combined dosage that is effective to decrease disease progression by at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, or more, compared with a placebo control or an untreated control.

[00687] Disease progression is the occurrence of one or more of the following: (1) a decrease in predicted FVC of 10% or more; (2) an increase in A-a gradient of 5 mm Hg or more; (3) a decrease of 15% or more in single breath DL<sub>co</sub>. Whether disease progression has occurred is determined by measuring one or more of these parameters on two consecutive occasions 4 to 14 weeks apart, and comparing the value to baseline.

[00688] Thus, e.g., where an untreated or placebo-treated individual exhibits a 50% decrease in FVC over a period of time, an individual administered with an effective combination of a synthetic Type I interferon receptor polypeptide agonist and a Type II interferon receptor agonist exhibits a decrease in FVC of 45%, about 42%, about 40%, about 37%, about 35%, about 32%, about 30%, or less, over the same time period.

[00689] In some embodiments, "effective amounts" of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that is effective to increase progression-free survival time, e.g., the time from baseline (e.g., a time point from 1 day to 28 days before beginning of treatment) to death or disease progression is increased by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 2-fold, at least about 3-fold, at least about 4-fold, at least about 5-fold, or more, compared a placebo-treated or an untreated control individual. Thus, e.g., in some embodiments effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that is effective to increase the progression-free survival time by at least about 1 week, at least about 2 weeks, at least about 3 weeks, at least about 4 weeks, at least about 2 months, at least about 3 months, at least about 4 months, at least about 5

months, at least about 6 months, at least about 8 months, at least about 10 months, at least about 12 months, at least about 18 months, at least about 2 years, at least about 3 years, or longer, compared to a placebo-treated or untreated control.

[00690] In some embodiments, effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that is effective to increase at least one parameter of lung function, e.g., a combined dosage that increases at least one parameter of lung function by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 2-fold, at least about 3-fold, at least about 4-fold, at least about 5-fold, or more, compared to an untreated individual or a placebo-treated control individual. In some of these embodiments, a determination of whether a parameter of lung function is increased is made by comparing the baseline value with the value at any time point after the beginning of treatment, e.g., 48 weeks after the beginning of treatment, or between two time points, e.g., about 4 to about 14 weeks apart, after the beginning of treatment.

[00691] In some embodiments, effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that is effective to increase the FVC by at least about 10% at least about 20%, at least about 25%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 2-fold, at least about 3-fold, at least about 4-fold, at least about 5-fold, or more compared to baseline on two consecutive occasions 4 to 14 weeks apart.

[00692] In some embodiments, effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that results in a decrease in alveolar:arterial (A-a) gradient of at least about 5 mm Hg, at least about 7 mm Hg, at least about 10 mm Hg, at least about 12 mm Hg, at least about 15 mm Hg, or more, compared to baseline.

[00693] In some embodiments, effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type

II interferon receptor agonist are any combined dosage that increases the single breath  $DL_{CO}$  by at least about 15 %, at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 2-fold, at least about 3-fold, at least about 4-fold, at least about 5-fold, or more, compared to baseline.  $CL_{CO}$  is the lung diffusing capacity for carbon monoxide, and is expressed as mL CO/mm Hg/second.

[00694] Parameters of lung function include, but are not limited to, forced vital capacity (FVC); forced expiratory volume ( $FEV_1$ ); total lung capacity; partial pressure of arterial oxygen at rest; partial pressure of arterial oxygen at maximal exertion.

[00695] Lung function can be measured using any known method, including, but not limited to spirometry.

*Liver fibrosis*

[00696] The present invention provides methods of treating liver fibrosis, including reducing clinical liver fibrosis, reducing the likelihood that liver fibrosis will occur, and reducing a parameter associated with liver fibrosis. The methods generally involve administering a combination of an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and an effective amount of a Type II interferon receptor agonist to an individual in need thereof. Of particular interest in many embodiments is treatment of humans.

[00697] Liver fibrosis is a precursor to the complications associated with liver cirrhosis, such as portal hypertension, progressive liver insufficiency, and hepatocellular carcinoma. A reduction in liver fibrosis thus reduces the incidence of such complications. Accordingly, the present invention further provides methods of reducing the likelihood that an individual will develop complications associated with cirrhosis of the liver.

[00698] The present methods generally involve administering therapeutically effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist. As used herein, "effective amounts" of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that is effective in reducing liver fibrosis or reducing the rate of progression of liver fibrosis; and/or that is effective in reducing the likelihood that an

individual will develop liver fibrosis; and/or that is effective in reducing a parameter associated with liver fibrosis; and/or that is effective in reducing a disorder associated with cirrhosis of the liver.

[00699] The invention also provides a method for treatment of liver fibrosis in an individual comprising administering to the individual an amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and an amount of Type II interferon receptor agonist that in combination are effective for prophylaxis or therapy of liver fibrosis in the individual, e.g., increasing the probability of survival, reducing the risk of death, ameliorating the disease burden or slowing the progression of disease in the individual.

[00700] Whether treatment with a combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist is effective in reducing liver fibrosis is determined by any of a number of well-established techniques for measuring liver fibrosis and liver function. Whether liver fibrosis is reduced is determined by analyzing a liver biopsy sample. An analysis of a liver biopsy comprises assessments of two major components: necroinflammation assessed by "grade" as a measure of the severity and ongoing disease activity, and the lesions of fibrosis and parenchymal or vascular remodeling as assessed by "stage" as being reflective of long-term disease progression. See, e.g., Brunt (2000) *Hepatology* 31:241-246; and METAVIR (1994) *Hepatology* 20:15-20. Based on analysis of the liver biopsy, a score is assigned. A number of standardized scoring systems exist which provide a quantitative assessment of the degree and severity of fibrosis. These include the METAVIR, Knodell, Scheuer, Ludwig, and Ishak scoring systems.

[00701] The METAVIR scoring system is based on an analysis of various features of a liver biopsy, including fibrosis (portal fibrosis, centrilobular fibrosis, and cirrhosis); necrosis (piecemeal and lobular necrosis, acidophilic retraction, and ballooning degeneration); inflammation (portal tract inflammation, portal lymphoid aggregates, and distribution of portal inflammation); bile duct changes; and the Knodell index (scores of periportal necrosis, lobular necrosis, portal inflammation, fibrosis, and overall disease activity). The definitions of each stage in the METAVIR system are as follows: score: 0, no fibrosis; score: 1, stellate enlargement of portal tract but without septa formation; score: 2, enlargement of portal tract with rare septa formation; score: 3, numerous septa without cirrhosis; and score: 4, cirrhosis.

- [00702] Knodell's scoring system, also called the Hepatitis Activity Index, classifies specimens based on scores in four categories of histologic features: I. Periportal and/or bridging necrosis; II. Intralobular degeneration and focal necrosis; III. Portal inflammation ; and IV. Fibrosis. In the Knodell staging system, scores are as follows: score: 0, no fibrosis; score: 1, mild fibrosis (fibrous portal expansion); score: 2, moderate fibrosis; score: 3, severe fibrosis (bridging fibrosis); and score: 4, cirrhosis. The higher the score, the more severe the liver tissue damage. Knodell (1981) *Hepatology*. 1:431.
- [00703] In the Scheuer scoring system scores are as follows: score: 0, no fibrosis; score: 1, enlarged, fibrotic portal tracts; score: 2, periportal or portal-portal septa, but intact architecture; score: 3, fibrosis with architectural distortion, but no obvious cirrhosis; score: 4, probable or definite cirrhosis. Scheuer (1991) *J. Hepatology*. 13:372.
- [00704] The Ishak scoring system is described in Ishak (1995) *J. Hepatology*. 22:696-699. Stage 0, No fibrosis; Stage 1, Fibrous expansion of some portal areas, with or without short fibrous septa; stage 2, Fibrous expansion of most portal areas, with or without short fibrous septa; stage 3, Fibrous expansion of most portal areas with occasional portal to portal (P-P) bridging; stage 4, Fibrous expansion of portal areas with marked bridging (P-P) as well as portal-central (P-C); stage 5, Marked bridging (P-P and/or P-C) with occasional nodules (incomplete cirrhosis); stage 6, Cirrhosis, probable or definite. The benefit of anti-fibrotic therapy can also be measured and assessed by using the Child-Pugh scoring system which comprises a multicomponent point system based upon abnormalities in serum bilirubin level, serum albumin level, prothrombin time, the presence and severity of ascites, and the presence and severity of encephalopathy. Based upon the presence and severity of abnormality of these parameters, patients may be placed in one of three categories of increasing severity of clinical disease: A, B, or C.
- [00706] In some embodiments, a therapeutically effective combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist is any combined dosage that effects a change of one unit or more in the fibrosis stage based on pre- and post-therapy liver biopsies. In particular embodiments, a therapeutically effective combined dosage reduces liver fibrosis by at least one unit in the METAVIR, the Knodell, the Scheuer, the Ludwig, or the Ishak scoring system.
- [00707] Secondary, or indirect, indices of liver function can also be used to evaluate the efficacy of treatment with a subject synthetic Type I interferon receptor polypeptide agonist, a



hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and Type II interferon receptor agonist. Morphometric computerized semi-automated assessment of the quantitative degree of liver fibrosis based upon specific staining of collagen and/or serum markers of liver fibrosis can also be measured as an indication of the efficacy of a subject treatment method. Secondary indices of liver function include, but are not limited to, serum transaminase levels, prothrombin time, bilirubin, platelet count, portal pressure, albumin level, and assessment of the Child-Pugh score.

[00708] In another embodiment, an effective combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist is any combined dosage that is effective to increase an index of liver function by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, or at least about 80%, or more, compared to the index of liver function in an untreated individual, or in a placebo-treated individual. Those skilled in the art can readily measure such indices of liver function, using standard assay methods, many of which are commercially available, and are used routinely in clinical settings.

[00709] Serum markers of liver fibrosis can also be measured as an indication of the efficacy of a subject treatment method. Serum markers of liver fibrosis include, but are not limited to, hyaluronate, N-terminal procollagen III peptide, 7S domain of type IV collagen, C-terminal procollagen I peptide, and laminin. Additional biochemical markers of liver fibrosis include  $\alpha$ -2-macroglobulin, haptoglobin, gamma globulin, apolipoprotein A, and gamma glutamyl transpeptidase.

[00710] In another embodiment, a therapeutically effective combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist is any combined dosage that is effective to reduce a serum level of a marker of liver fibrosis by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, or at least about 80%, or more, compared to the level of the marker in an untreated individual, or in a placebo-treated individual. Those skilled in the art can readily

measure such serum markers of liver fibrosis, using standard assay methods, many of which are commercially available, and are used routinely in clinical settings. Methods of measuring serum markers include immunological-based methods, e.g., enzyme-linked immunosorbent assays (ELISA), radioimmunoassays, and the like, using antibody specific for a given serum marker.

[00711] Quantitative tests of functional liver reserve can also be used to assess the efficacy of treatment with a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist. These include: indocyanine green clearance (ICG), galactose elimination capacity (GEC), aminopyrine breath test (ABT), antipyrine clearance, monoethylglycine-xylidide (MEG-X) clearance, and caffeine clearance.

[00712] As used herein, a "complication associated with cirrhosis of the liver" refers to a disorder that is a sequellae of decompensated liver disease, i.e., or occurs subsequently to and as a result of development of liver fibrosis, and includes, but it not limited to, development of ascites, variceal bleeding, portal hypertension, jaundice, progressive liver insufficiency, encephalopathy, hepatocellular carcinoma, liver failure requiring liver transplantation, and liver-related mortality.

[00713] In another embodiment, a therapeutically effective combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist is any combined dosage that is effective in reducing the incidence of (e.g., the likelihood that an individual will develop) a disorder associated with cirrhosis of the liver by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, or at least about 80%, or more, compared to an untreated individual, or in a placebo-treated individual.

[00714] Whether combination therapy with a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist is effective in reducing the incidence of a disorder associated with cirrhosis of the liver can readily be determined by those skilled in the art.

[00715] Reduction in liver fibrosis increases liver function. Thus, the invention provides methods for increasing liver function, generally involving administering a therapeutically effective combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist. Liver functions include, but are not limited to, synthesis of proteins such as serum proteins (e.g., albumin, clotting factors, alkaline phosphatase, aminotransferases (e.g., alanine transaminase, aspartate transaminase), 5'-nucleosidase,  $\gamma$ -glutaminylnitrilase, etc.), synthesis of bilirubin, synthesis of cholesterol, and synthesis of bile acids; a liver metabolic function, including, but not limited to, carbohydrate metabolism, amino acid and ammonia metabolism, hormone metabolism, and lipid metabolism; detoxification of exogenous drugs; a hemodynamic function, including splanchnic and portal hemodynamics; and the like.

[00716] Whether a liver function is increased is readily ascertainable by those skilled in the art, using well-established tests of liver function. Thus, synthesis of markers of liver function such as albumin, alkaline phosphatase, alanine transaminase, aspartate transaminase, bilirubin, and the like, can be assessed by measuring the level of these markers in the serum, using standard immunological and enzymatic assays. Splanchnic circulation and portal hemodynamics can be measured by portal wedge pressure and/or resistance using standard methods. Metabolic functions can be measured by measuring the level of ammonia in the serum.

[00717] Whether serum proteins normally secreted by the liver are in the normal range can be determined by measuring the levels of such proteins, using standard immunological and enzymatic assays. Those skilled in the art know the normal ranges for such serum proteins. The following are non-limiting examples. The normal range of alanine transaminase is from about 7 to about 56 units per liter of serum. The normal range of aspartate transaminase is from about 5 to about 40 units per liter of serum. Bilirubin is measured using standard assays. Normal bilirubin levels are usually less than about 1.2 mg/dL. Serum albumin levels are measured using standard assays. Normal levels of serum albumin are in the range of from about 35 to about 55 g/L. Prolongation of prothrombin time is measured using standard assays. Normal prothrombin time is less than about 4 seconds longer than control.

[00718] In another embodiment, a therapeutically effective combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist is any combined dosage that is effective to increase liver function by at least about 10%, at least about 20%, at least about 30%, at least

about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, or more. For example, a therapeutically effective combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist includes any combined dosage that is effective to reduce an elevated level of a serum marker of liver function by at least about 10%, at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, or more, or to reduce the level of the serum marker of liver function to within a normal range. A therapeutically effective combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist also includes any combined dosage effective to increase a reduced level of a serum marker of liver function by at least about 10%, at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, or more, or to increase the level of the serum marker of liver function to within a normal range.

#### *Renal fibrosis*

[00719] The present invention provides methods of treating renal fibrosis. The methods generally involve administering to an individual having renal fibrosis effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist. As used herein, “effective amounts” of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that is effective in reducing renal fibrosis; and/or that is effective in reducing the likelihood that an individual will develop renal fibrosis; and/or that is effective in reducing a parameter associated with renal fibrosis; and/or that is effective in reducing a disorder associated with fibrosis of the kidney.

[00720] In one embodiment, effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that is sufficient to reduce renal fibrosis, or reduce the rate of progression of renal fibrosis, by at least about 10%, at least about 15%, at least

about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, compared to the degree of renal fibrosis in the individual prior to treatment, or compared to the rate of progression of renal fibrosis that would have been experienced by the patient in the absence of treatment.

[00721] Whether fibrosis is reduced in the kidney is determined using any known method. For example, histochemical analysis of kidney biopsy samples for the extent of ECM deposition and/or fibrosis is performed. Other methods are known in the art. See, e.g., Masseroli et al. (1998) *Lab. Invest.* 78:511-522; U.S. Patent No. 6,214,542.

[00722] In some embodiments, effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that is effective to increase kidney function by at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, compared to the baseline level of kidney function in the individual prior to treatment.

[00723] In some embodiments, effective amounts of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist are any combined dosage that is effective to slow the decline in kidney function by at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, compared to the decline in kidney function that would occur in the absence of treatment.

[00724] Kidney function can be measured using any known assay, including, but not limited to, plasma creatinine level (where normal levels are generally in a range of from about 0.6 to about 1.2 mg/dL); creatinine clearance (where the normal range for creatinine clearance is from about 97 to about 137 mL/minute in men, and from about 88 to about 128 mL/minute in women); the glomerular filtration rate (either calculated or obtained from inulin clearance or other methods), blood urea nitrogen (where the normal range is from about 7 to about 20 mg/dL); and urine protein levels.

#### **Additional Anti-Fibrotic Agents**

[00725] Any of the above-described combination therapies for the treatment of a fibrotic disorder can be modified to include co-administration of one or more additional anti-fibrotic agents. Accordingly, the present invention provides a method of treating a fibrotic disorder,

generally involving administering a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist in combination therapy with at least one additional anti-fibrotic agent. Suitable additional anti-fibrotic agents include, but are not limited to, SAPK inhibitors (e.g., pirfenidone or pirfenidone analogs), TNF antagonists, TGF- $\beta$  antagonists, endothelin receptor antagonists, and the like.

[00726] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00727] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of an amount of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00728] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of an amount of a TGF- $\beta$  antagonist (e.g., GLEEVEC) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

- [00729] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of an amount of an endothelin receptor antagonist (e.g., TRACLEER) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.
- [00730] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) and a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.
- [00731] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) and a TGF- $\beta$  antagonist (e.g., GLEEVEC) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.
- [00732] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a SAPK inhibitor (e.g., pirfenidone or

a pirfenidone analog) and an endothelin receptor antagonist (e.g., TRACLEER) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00733] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) and a TGF- $\beta$  antagonist (e.g., GLEEVEC) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00734] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) and an endothelin receptor antagonist (e.g., TRACLEER) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00735] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a TGF- $\beta$  antagonist (e.g., GLEEVEC) and an endothelin receptor antagonist (e.g., TRACLEER) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00736] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a



hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog), TNF antagonist (e.g., etanercept, infliximab, or adalimumab) and a TGF- $\beta$  antagonist (e.g., GLEEVEC) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00737] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog), TNF antagonist (e.g., etanercept, infliximab, or adalimumab) and an endothelin antagonist (e.g., TRACLEER) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00738] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of TNF antagonist (e.g., etanercept, infliximab, or adalimumab), TGF- $\beta$  antagonist (e.g., GLEEVEC) and an endothelin antagonist (e.g., TRACLEER) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00739] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog), TGF- $\beta$  antagonist (e.g., GLEEVEC) and an endothelin antagonist (e.g.,

TRACLEER) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00740] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient can be modified to include co-administration to the patient of a combined dosage of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog), a TNF antagonist (e.g., etanercept, infliximab, or adalimumab), a TGF- $\beta$  antagonist (e.g., GLEEVEC) and an endothelin antagonist (e.g., TRACLEER) effective to augment the anti-fibrotic effect of the synthetic Type I interferon receptor polypeptide agonist and Type II interferon receptor agonist combination therapy, for the desired treatment duration.

[00741] As non-limiting examples, any of the above-described treatment methods featuring therapy with a combined dosage of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a Type II interferon receptor agonist effective for the treatment of a fibrotic disorder in a patient, with or without co-administration of one or more additional anti-fibrotic agent(s), can be further modified to include co-administration of an amount of N-acetylcysteine (NAC) effective to augment the anti-fibrotic effect of the combination therapy, for the desired treatment duration.

#### CANCER

[00742] The present invention provides a method of treating a proliferative disorder (e.g., cancer), the method generally involving administering to an individual in need thereof an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant.

[00743] The methods are effective to reduce the growth rate of a tumor by at least about 5%, at least about 10%, at least about 20%, at least about 25%, at least about 50%, at least about 75%, at least about 85%, or at least about 90%, up to total inhibition of growth of the tumor, when compared to a suitable control. Thus, in these embodiments, an "effective amount" of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant is an amount that is sufficient to reduce tumor growth rate by at least about

5%, at least about 10%, at least about 20%, at least about 25%, at least about 50%, at least about 75%, at least about 85%, or at least about 90%, up to total inhibition of tumor growth, when compared to a suitable control. In an experimental animal system, a suitable control may be a genetically identical animal not treated with the synthetic Type I interferon receptor polypeptide agonist. In non-experimental systems, a suitable control may be the tumor load present before administering the synthetic Type I interferon receptor polypeptide agonist. Other suitable controls may be a placebo control.

[00744] Whether growth of a tumor is inhibited can be determined using any known method, including, but not limited to, a proliferation assay as described in the Example; a <sup>3</sup>H-thymidine uptake assay; and the like.

[00745] The methods are useful for treating a wide variety of cancers, including carcinomas, sarcomas, leukemias, and lymphomas.

[00746] Carcinomas that can be treated using a subject method include, but are not limited to, esophageal carcinoma, hepatocellular carcinoma, basal cell carcinoma (a form of skin cancer), squamous cell carcinoma (various tissues), bladder carcinoma, including transitional cell carcinoma (a malignant neoplasm of the bladder), bronchogenic carcinoma, colon carcinoma, colorectal carcinoma, gastric carcinoma, lung carcinoma, including small cell carcinoma and non-small cell carcinoma of the lung, adrenocortical carcinoma, thyroid carcinoma, pancreatic carcinoma, breast carcinoma, ovarian carcinoma, prostate carcinoma, adenocarcinoma, sweat gland carcinoma, sebaceous gland carcinoma, papillary carcinoma, papillary adenocarcinoma, cystadenocarcinoma, medullary carcinoma, renal cell carcinoma, ductal carcinoma in situ or bile duct carcinoma, choriocarcinoma, seminoma, embryonal carcinoma, Wilm's tumor, cervical carcinoma, uterine carcinoma, testicular carcinoma, osteogenic carcinoma, epithelial carcinoma, and nasopharyngeal carcinoma, etc.

[00747] Sarcomas that can be treated using a subject method include, but are not limited to, fibrosarcoma, myxosarcoma, liposarcoma, chondrosarcoma, chordoma, osteogenic sarcoma, osteosarcoma, angiosarcoma, endotheliosarcoma, lymphangiosarcoma, lymphangioendotheliosarcoma, synovioma, mesothelioma, Ewing's sarcoma, leiomyosarcoma, rhabdomyosarcoma, and other soft tissue sarcomas.

[00748] Other solid tumors that can be treated using a subject method include, but are not limited to, glioma, astrocytoma, medulloblastoma, craniopharyngioma, ependymoma, pinealoma, hemangioblastoma, acoustic neuroma, oligodendroglioma, menangioma, melanoma, neuroblastoma, and retinoblastoma.

[00749] Leukemias that can be treated using a subject method include, but are not limited to, a) chronic myeloproliferative syndromes (neoplastic disorders of multipotential hematopoietic stem cells); b) acute myelogenous leukemias (neoplastic transformation of a multipotential hematopoietic stem cell or a hematopoietic cell of restricted lineage potential; c) chronic lymphocytic leukemias (CLL; clonal proliferation of immunologically immature and functionally incompetent small lymphocytes), including B-cell CLL, T-cell CLL, prolymphocytic leukemia, and hairy cell leukemia; and d) acute lymphoblastic leukemias (characterized by accumulation of lymphoblasts). Lymphomas that can be treated using a subject method include, but are not limited to, B-cell lymphomas (e.g., Burkitt's lymphoma); Hodgkin's lymphoma; and the like.

#### **Combination therapies**

[00750] In some embodiments, the present invention provides combination therapies for the treatment of cancer. Accordingly, the present invention provides a method of treating cancer, generally involving administering a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant in combination therapy with at least a second therapeutic agent.

[00751] In other embodiments, the present invention provides methods of treating cancer that involve administering a synergistic combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a second therapeutic agent. As used herein, a "synergistic combination" of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and a second therapeutic agent is a combined dosage that is more effective in the therapeutic or prophylactic treatment of cancer than the incremental improvement in treatment outcome that could be predicted or expected from a merely additive combination of (i) the therapeutic or prophylactic benefit of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant when administered at that same dosage as a monotherapy and (ii) the therapeutic or prophylactic benefit of the second therapeutic agent when administered at the same dosage as a monotherapy.

[00752] In some embodiments, a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a

hyperglycosylated, protease-resistant polypeptide variant is administered as an adjuvant therapy to a standard cancer therapy. Standard cancer therapies include surgery (e.g., surgical removal of cancerous tissue), radiation therapy, bone marrow transplantation, chemotherapeutic treatment, biological response modifier treatment, and certain combinations of the foregoing.

- [00753] Radiation therapy includes, but is not limited to, x-rays or gamma rays that are delivered from either an externally applied source such as a beam, or by implantation of small radioactive sources.
- [00754] Chemotherapeutic agents are non-peptidic (i.e., non-proteinaceous) compounds that reduce proliferation of cancer cells, and encompass cytotoxic agents and cytostatic agents. Non-limiting examples of chemotherapeutic agents include alkylating agents, nitrosoureas, antimetabolites, antitumor antibiotics, plant (vinca) alkaloids, and steroid hormones.
- [00755] Agents that act to reduce cellular proliferation are known in the art and widely used. Such agents include alkylating agents, such as nitrogen mustards, nitrosoureas, ethylenimine derivatives, alkyl sulfonates, and triazenes, including, but not limited to, mechlorethamine, cyclophosphamide (Cytosan<sup>TM</sup>), melphalan (L-sarcosine), carmustine (BCNU), lomustine (CCNU), semustine (methyl-CCNU), streptozocin, chlorozotocin, uracil mustard, chlormethine, ifosfamide, chlorambucil, pipobroman, triethylenemelamine, triethylenethiophosphoramine, busulfan, dacarbazine, and temozolomide.
- [00756] Antimetabolite agents include folic acid analogs, pyrimidine analogs, purine analogs, and adenosine deaminase inhibitors, including, but not limited to, cytarabine (CYTOSAR-U), cytosine arabinoside, fluorouracil (5-FU), floxuridine (FudR), 6-thioguanine, 6-mercaptopurine (6-MP), pentostatin, 5-fluorouracil (5-FU), methotrexate, 10-propargyl-5,8-dideazafolate (PDDF, CB3717), 5,8-dideazatetrahydrofolic acid (DDATHF), leucovorin, fludarabine phosphate, pentostatin, and gemcitabine.
- [00757] Suitable natural products and their derivatives, (e.g., vinca alkaloids, antitumor antibiotics, enzymes, lymphokines, and epipodophyllotoxins), include, but are not limited to, Ara-C, paclitaxel (Taxol®), docetaxel (Taxotere®), deoxycoformycin, mitomycin-C, L-asparaginase, azathioprine; brequinar; alkaloids, e.g. vincristine, vinblastine, vinorelbine, vindesine, *etc.*; podophyllotoxins, e.g. etoposide, teniposide, *etc.*; antibiotics, e.g. anthracycline, daunorubicin hydrochloride (daunomycin, rubidomycin, cerubidine), idarubicin, doxorubicin, epirubicin and morpholino derivatives, *etc.*; phenoxizone biscyclopeptides, e.g. dactinomycin; basic glycopeptides, e.g. bleomycin; anthraquinone glycosides, e.g. plicamycin (mithramycin); anthracenediones, e.g. mitoxantrone; azirinopyrrolo indoleiones, e.g.

mitomycin; macrocyclic immunosuppressants, *e.g.* cyclosporine, FK-506 (tacrolimus, prograf), rapamycin, *etc.*; and the like.

[00758] Other anti-proliferative cytotoxic agents are navelbene, CPT-11, anastrozole, letrozole, capecitabine, reloxafine, cyclophosphamide, ifosamide, and droloxafine.

[00759] Microtubule affecting agents that have antiproliferative activity are also suitable for use and include, but are not limited to, allocolchicine (NSC 406042), Halichondrin B (NSC 609395), colchicine (NSC 757), colchicine derivatives (*e.g.*, NSC 33410), dolstatin 10 (NSC 376128), maytansine (NSC 153858), rhizoxin (NSC 332598), paclitaxel (Taxol®), Taxol® derivatives, docetaxel (Taxotere®), thiocolchicine (NSC 361792), trityl cysterin, vinblastine sulfate, vincristine sulfate, natural and synthetic epothilones including but not limited to, eopthilone A, epothilone B, discodermolide; estramustine, nocodazole, and the like.

[00760] Hormone modulators and steroids (including synthetic analogs) that are suitable for use include, but are not limited to, adrenocorticosteroids, *e.g.* prednisone, dexamethasone, *etc.*; estrogens and progestins, *e.g.* hydroxyprogesterone caproate, medroxyprogesterone acetate, megestrol acetate, estradiol, clomiphene, tamoxifen; *etc.*; and adrenocortical suppressants, *e.g.* aminoglutethimide; 17 $\alpha$ -ethinylestradiol; diethylstilbestrol, testosterone, fluoxymesterone, dromostanolone propionate, testolactone, methylprednisolone, methyl-testosterone, prednisolone, triamcinolone, chlorotrianisene, hydroxyprogesterone, aminoglutethimide, estramustine, medroxyprogesterone acetate, leuprolide, Flutamide (Drogenil), Toremifene (Fareston), and Zoladex®. Estrogens stimulate proliferation and differentiation, therefore compounds that bind to the estrogen receptor are used to block this activity. Corticosteroids may inhibit T cell proliferation.

[00761] Other chemotherapeutic agents include metal complexes, *e.g.* cisplatin (cis-DDP), carboplatin, *etc.*; ureas, *e.g.* hydroxyurea; and hydrazines, *e.g.* N-methylhydrazine; epidophyllotoxin; a topoisomerase inhibitor; procarbazine; mitoxantrone; leucovorin; tegafur; *etc.* Other anti-proliferative agents of interest include immunosuppressants, *e.g.* mycophenolic acid, thalidomide, desoxyspergualin, azasporine, leflunomide, mizoribine, azaspirane (SKF 105685); Iressa® (ZD 1839, 4-(3-chloro-4-fluorophenylamino)-7-methoxy-6-(3-(4-morpholinyl)propoxy)quinazoline); *etc.*

[00762] "Taxanes" include paclitaxel, as well as any active taxane derivative or pro-drug. "Paclitaxel" (which should be understood herein to include analogues, formulations, and derivatives such as, for example, docetaxel, TAXOL™, TAXOTERE™ (a formulation of docetaxel), 10-desacetyl analogs of paclitaxel and 3'N-desbenzoyl-3'N-t-butoxycarbonyl analogs of paclitaxel) may be readily prepared utilizing techniques known to those skilled in

the art (see also WO 94/07882, WO 94/07881, WO 94/07880, WO 94/07876, WO 93/23555, WO 93/10076; U.S. Pat. Nos. 5,294,637; 5,283,253; 5,279,949; 5,274,137; 5,202,448; 5,200,534; 5,229,529; and EP 590,267), or obtained from a variety of commercial sources, including for example, Sigma Chemical Co., St. Louis, Mo. (T7402 from *Taxus brevifolia*; or T-1912 from *Taxus yunnanensis*).

[00763] Paclitaxel should be understood to refer to not only the common chemically available form of paclitaxel, but analogs and derivatives (e.g., Taxotere™ docetaxel, as noted above) and paclitaxel conjugates (e.g., paclitaxel-PEG, paclitaxel-dextran, or paclitaxel-xylose).

[00764] Also included within the term "taxane" are a variety of known derivatives, including both hydrophilic derivatives, and hydrophobic derivatives. Taxane derivatives include, but not limited to, galactose and mannose derivatives described in International Patent Application No. WO 99/18113; piperazino and other derivatives described in WO 99/14209; taxane derivatives described in WO 99/09021, WO 98/22451, and U.S. Patent No. 5,869,680; 6-thio derivatives described in WO 98/28288; sulfenamide derivatives described in U.S. Patent No. 5,821,263; and taxol derivative described in U.S. Patent No. 5,415,869. It further includes prodrugs of paclitaxel including, but not limited to, those described in WO 98/58927; WO 98/13059; and U.S. Patent No. 5,824,701.

[00765] Biological response modifiers suitable for use in connection with the methods of the invention include, but are not limited to, (1) inhibitors of tyrosine kinase (RTK) activity; (2) inhibitors of serine/threonine kinase activity; (3) tumor-associated antigen antagonists, such as antibodies that bind specifically to a tumor antigen; (4) apoptosis receptor agonists; (5) interleukin-2; (6) IFN- $\alpha$ ; (7) IFN- $\gamma$  (8) colony-stimulating factors; and (9) inhibitors of angiogenesis.

[00766] In one aspect, the invention contemplates the combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant as an adjuvant to any therapy in which the cancer patient receives treatment with at least one additional antineoplastic drug, where the additional drug is a tyrosine kinase inhibitor. In some embodiments, the tyrosine kinase inhibitor is a receptor tyrosine kinase (RTK) inhibitor, such as type I receptor tyrosine kinase inhibitors (e.g., inhibitors of epidermal growth factor receptors), type II receptor tyrosine kinase inhibitors (e.g., inhibitors of insulin receptor), type III receptor tyrosine kinase inhibitors (e.g., inhibitors of platelet-derived growth factor receptor), and type IV receptor tyrosine kinase inhibitors (e.g., fibroblast growth factor

receptor). In other embodiments, the tyrosine kinase inhibitor is a non-receptor tyrosine kinase inhibitor, such as inhibitors of src kinases or janus kinases.

[00767] In another aspect, the invention contemplates the combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant as an adjuvant to any therapy in which the cancer patient receives treatment with at least one additional antineoplastic drug, where the additional drug is an inhibitor of a receptor tyrosine kinase involved in growth factor signaling pathway(s). In some embodiments, the inhibitor is genistein. In other embodiments, the inhibitor is an EGFR tyrosine kinase-specific antagonist, such as IRESSA™ gefitinib (ZD18398; Novartis), TARCEVA™ erlotinib (OSI-774; Roche; Genentech; OSI Pharmaceuticals), or tyrphostin AG1478 (4-(3-chloroanilino)-6,7-dimethoxyquinazoline. In still other embodiments, the inhibitor is any indolinone antagonist of Flk-1/KDR (VEGF-R2) tyrosine kinase activity described in U.S. Patent Application Publication No. 2002/0183364 A1, such as the indolinone antagonists of Flk-1/KDR (VEGF-R2) tyrosine kinase activity disclosed in Table 1 on pages 4-5 thereof. In further embodiments, the inhibitor is any of the substituted 3-[(4,5,6,7-tetrahydro-1H-indol-2-yl) methylene]-1,3-dihydroindol-2-one antagonists of Flk-1/KDR (VEGF-R2), FGF-R1 or PDGF-R tyrosine kinase activity disclosed in Sun, L., et al., *J. Med. Chem.*, 43(14): 2655-2663 (2000). In additional embodiments, the inhibitor is any substituted 3-[(3- or 4-carboxyethylpyrrol-2-yl) methylidenyl]indolin-2-one antagonist of Flt-1 (VEGF-R1), Flk-1/KDR (VEGF-R2), FGF-R1 or PDGF-R tyrosine kinase activity disclosed in Sun, L., et al., *J. Med. Chem.*, 42(25): 5120-5130 (1999).

[00768] In another aspect, the invention contemplates the combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant as an adjuvant to any therapy in which the cancer patient receives treatment with at least one additional antineoplastic drug, where the additional drug is an inhibitor of a non-receptor tyrosine kinase involved in growth factor signaling pathway(s). In some embodiments, the inhibitor is an antagonist of JAK2 tyrosine kinase activity, such as tyrphostin AG490 (2-cyano-3-(3,4-dihydroxyphenyl)-N-(benzyl)-2-propenamide). In other embodiments, the inhibitor is an antagonist of bcr-abl tyrosine kinase activity, such as GLEEVEC™ imatinib mesylate (STI-571; Novartis).

[00769] In another aspect, the invention contemplates the combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a



protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant as an adjuvant to any therapy in which the cancer patient receives treatment with at least one additional antineoplastic drug, where the additional drug is an inhibitor of one or more kinases involved in cell cycle regulation. In some embodiments, the inhibitor is an antagonist of CDK2 activation, such as tryphostin AG490 (2-cyano-3-(3,4-dihydroxyphenyl)-N-(benzyl)-2-propenamide). In other embodiments, the inhibitor is an antagonist of CDK1/cyclin B activity, such as alsterpaullone. In still other embodiments, the inhibitor is an antagonist of CDK2 kinase activity, such as indirubin-3'-monoxime. In additional embodiments, the inhibitor is an ATP pool antagonist, such as lometrexol (described in U.S. Patent Application Publication No. 2002/0156023 A1).

[00770] In another aspect, the invention contemplates the combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant as an adjuvant to any therapy in which the cancer patient receives treatment with at least one additional antineoplastic drug, where the additional drug is a tumor-associated antigen antagonist, such as an antibody antagonist. In some embodiments involving the treatment of HER2-expressing tumors, the tumor-associated antigen antagonist is an anti-HER2 monoclonal antibody, such as HERCEPTIN™ trastuzumab. In some embodiments involving the treatment of CD20-expressing tumors, such as B-cell lymphomas, the tumor-associated antigen antagonist is an anti-CD20 monoclonal antibody, such as RITUXAN™ rituximab.

[00771] In another aspect, the invention contemplates the combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant as an adjuvant to any therapy in which the cancer patient receives treatment with at least one additional antineoplastic drug, where the additional drug is a tumor growth factor antagonist. In some embodiments, the tumor growth factor antagonist is an antagonist of epidermal growth factor (EGF), such as an anti-EGF monoclonal antibody. In other embodiments, the tumor growth factor antagonist is an antagonist of epidermal growth factor receptor erbB1 (EGFR), such as an anti-EGFR monoclonal antibody inhibitor of EGFR activation or signal transduction, e.g. ERBITUX™ cetuximab.

[00772] In another aspect, the invention contemplates the combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide

variant as an adjuvant to any therapy in which the cancer patient receives treatment with at least one additional antineoplastic drug, where the additional drug is an Apo-2 ligand agonist. In some embodiments, the Apo-2 ligand agonist is any of the Apo-2 ligand polypeptides described in WO 97/25428.

[00773] In another aspect, the invention contemplates the combination of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant as an adjuvant to any therapy in which the cancer patient receives treatment with at least one additional antineoplastic drug, where the additional drug is an anti-angiogenic agent. In some embodiments, the anti-angiogenic agent is a vascular endothelial cell growth factor (VEGF) antagonist, such as an anti-VEGF monoclonal antibody, e.g. AVASTIN™ bevacizumab (Genentech). In other embodiments, the anti-angiogenic agent is an antagonist of VEGF-R1, such as an anti-VEGF-R1 monoclonal antibody. In other embodiments, the anti-angiogenic agent is an antagonist of VEGF-R2, such as an anti-VEGF-R2 monoclonal antibody. In other embodiments, the anti-angiogenic agent is an antagonist of basic fibroblast growth factor (bFGF), such as an anti-bFGF monoclonal antibody. In other embodiments, the anti-angiogenic factor is an antagonist of bFGF receptor, such as an anti-bFGF receptor monoclonal antibody. In other embodiments, the anti-angiogenic agent is an antagonist of TGF- $\beta$ , such as an anti-TGF- $\beta$  monoclonal antibody. In other embodiments, the anti-angiogenic agent is an antagonist of TGF- $\beta$  receptor, such as an anti-TGF- $\beta$  receptor monoclonal antibody. In other embodiments, the anti-angiogenic agent is a retinoic acid receptor (RXR) ligand, such as any RXR ligand described in U.S. Patent Application Publication No. 2001/0036955 A1 or in any of U.S. Pat. Nos. 5,824,685; 5,780,676; 5,399,586; 5,466,861; 4,810,804; 5,770,378; 5,770,383; or 5,770,382. In still other embodiments, the anti-angiogenic agent is a peroxisome proliferator-activated receptor (PPAR) gamma ligand, such as any PPAR gamma ligand described in U.S. Patent Application Publication No. 2001/0036955 A1.

[00774] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of cancer in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  effective to augment the anti-cancer effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

- [00775] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of cancer in a patient can be modified to include co-administration to the patient of an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-cancer effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.
- [00776] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of cancer in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-cancer effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.
- [00777] As non-limiting examples, any of the above-described treatment methods featuring combination therapy with an amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and an amount of an additional anti-cancer agent, other than IFN- $\gamma$ , effective for the treatment of cancer in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  effective to augment the anti-cancer effect of the synthetic Type I interferon receptor polypeptide agonist and additional anti-cancer agent combination therapy, for the desired treatment duration.
- [00778] As non-limiting examples, any of the above-described treatment methods featuring combination therapy with an amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and an amount of an additional anti-cancer agent, other than a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog), effective for the treatment of cancer in a patient can be modified to include co-administration to the patient of an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-cancer effect of the synthetic Type I interferon receptor polypeptide agonist and additional anti-cancer agent combination therapy, for the desired treatment duration.

[00779] As non-limiting examples, any of the above-described treatment methods featuring combination therapy with an amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant and an amount of an additional anti-cancer agent, other than IFN- $\gamma$  or a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog), effective for the treatment of cancer in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) that are effective to augment the anti-cancer effect of the synthetic Type I interferon receptor polypeptide agonist and additional anti-cancer agent combination therapy, for the desired treatment duration.

#### VIRAL INFECTIONS

[00780] The present invention provides methods of treating a virus infection, and methods of reducing viral load, or reducing the time to viral clearance, or reducing morbidity or mortality in the clinical outcomes, in patients suffering from a virus infection. The present invention further provides methods of reducing the risk that an individual will develop a pathological viral infection that has clinical sequelae. The methods generally involve administering a therapeutically effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of a virus infection.

[00781] In some embodiments, a subject treatment method is prophylactic. Where a subject treatment method is prophylactic, the methods reduce the risk that an individual will develop pathological infection with a virus. An effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant is an amount that reduces the risk or reduces the probability that an individual will develop a pathological infection with a virus. For example, an effective amount reduces the risk that an individual will develop a pathological infection by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, or more, compared to the risk of developing a pathological infection with the virus in the absence of treatment with a subject agent.

[00782] In some embodiments, an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant is an amount

that reduces viral load by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, or more, compared to the viral load in the absence of treatment with the subject agent.

[00783] In some embodiments, an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant is an amount that reduces the time to viral clearance, by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, or more, compared to the time to viral clearance in the absence of treatment.

[00784] In some embodiments, an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant is an amount that reduces morbidity or mortality due to a virus infection by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, or more, compared to the morbidity or mortality in the absence of treatment.

[00785] Whether a subject treatment method is effective in reducing the risk of a pathological virus infection, reducing viral load, reducing time to viral clearance, or reducing morbidity or mortality due to a virus infection is readily determined by those skilled in the art. Viral load is readily measured by measuring the titer or level of virus in serum. The number of virus in the serum can be determined using any known assay, including, e.g., a quantitative polymerase chain reaction assay using oligonucleotide primers specific for the virus being assayed. Whether morbidity is reduced can be determined by measuring any symptom associated with a virus infection, including, e.g., fever, respiratory symptoms (e.g., cough, ease or difficulty of breathing, and the like.)

[00786] In some embodiments, the present invention provides a method of reducing viral load, and/or reducing the time to viral clearance, and/or reducing morbidity or mortality in an individual who has been exposed to a virus (e.g., an individual who has come into contact with an individual infected with a virus), the method involving administering an effective amount of subject synthetic Type I interferon receptor polypeptide agonist. In these embodiments, therapy is begun from about 1 hour to about 14 days following exposure, e.g., from about 1 hour to about 24 hours, from about 24 hours to about 48 hours, from about 48 hours to about 3

days, from about 3 days to about 4 days, from about 4 days to about 7 days, from about 7 days to about 10 days, or from about 10 days to about 14 days following exposure to the virus.

[00787] In some embodiments, the present invention provides a method of reducing the risk that an individual who has been exposed to a virus (e.g., an individual who has come into contact with an individual infected with a virus) will develop a pathological virus infection with clinical sequelae, the method involving administering an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant. In these embodiments, therapy is begun from about 1 hour to about 35 days following exposure, e.g., from about 1 hour to about 24 hours, from about 24 hours to about 48 hours, from about 48 hours to about 3 days, from about 3 days to about 4 days, from about 4 days to about 7 days, from about 7 days to about 10 days, from about 10 days to about 14 days, from about 14 days to about 21 days, or from about 21 days to about 35 days following exposure to the virus.

[00788] In some embodiments, the present invention provides methods of reducing viral load, and/or reducing the time to viral clearance, and/or reducing morbidity or mortality in an individual who may or may not have been infected with a virus, and who has been exposed to a virus. In some of these embodiments, the methods involve administering an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant within 24 hours of exposure to the virus.

[00789] In some embodiments, the present invention provides methods of reducing viral load, and/or reducing the time to viral clearance, and/or reducing morbidity or mortality in an individual who has not been infected with a virus, and who has been exposed to a virus. In some of these embodiments, the methods involve administering effective amounts of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) and a Type I interferon receptor agonist within 48 hours of exposure to the virus.

[00790] In some embodiments, the present invention provides methods of reducing viral load, and/or reducing the time to viral clearance, and/or reducing morbidity or mortality in an individual who has not been infected with a virus, and who has been exposed to a virus. The methods involve administering a subject agent more than 48 hours after exposure to the virus, e.g., from 72 hours to about 35 days, e.g., 72 hours, 4 days, 5 days, 6 days, or 7 days after exposure, or from about 7 days to about 10 days, from about 10 days to about 14 days, from about 14 days to about 17 days, from about 17 days to about 21 days, from about 21 days to

about 25 days, from about 25 days to about 30 days, or from about 30 days to about 35 days after exposure to the virus. In some of these embodiments, the methods involve administering an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant more than 48 hours after exposure to the virus.

[00791] In some embodiments, the present invention provides a method of reducing the risk that an individual who has been exposed to a virus will develop a pathological virus infection with clinical sequelae. In some of these embodiments, the methods involve administering an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant within 24 hours of exposure to the virus.

[00792] In some embodiments, the present invention provides a method of reducing the risk that an individual who has been exposed to a virus (e.g., an individual who has come into contact with an individual infected with a virus) will develop a pathological viral infection with clinical sequelae. In some of these embodiments, the methods involve administering an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant within 48 hours of exposure to the virus.

#### **Hepatitis virus infection**

[00793] The present invention provides methods of treating a hepatitis virus infection. In particular embodiments, the present invention provides methods of treating a hepatitis C virus (HCV) infection; methods of reducing the incidence of complications associated with HCV and cirrhosis of the liver; and methods of reducing viral load, or reducing the time to viral clearance, or reducing morbidity or mortality in the clinical outcomes, in patients suffering from HCV infection. The methods generally involve administering to the individual an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant.

[00794] In many embodiments, a subject treatment method is effective to decrease viral load in the individual, and to achieve a sustained viral response. Optionally, the subject method further provides administering to the individual an effective amount of a nucleoside analog,

such as ribavirin, levovirin, and viramidine. Of particular interest in many embodiments is treatment of humans.

[00795] Whether a subject method is effective in treating an HCV infection can be determined by measuring viral load, or by measuring a parameter associated with HCV infection, including, but not limited to, liver fibrosis, elevations in serum transaminase levels, and necroinflammatory activity in the liver. Indicators of liver fibrosis are discussed in detail below.

[00796] Viral load can be measured by measuring the titer or level of virus in serum. These methods include, but are not limited to, a quantitative polymerase chain reaction (PCR) and a branched DNA (bDNA) test. Quantitative assays for measuring the viral load (titer) of HCV RNA have been developed. Many such assays are available commercially, including a quantitative reverse transcription PCR (RT-PCR) (Amplicor HCV Monitor™, Roche Molecular Systems, New Jersey); and a branched DNA (deoxyribonucleic acid) signal amplification assay (Quantiplex™ HCV RNA Assay (bDNA), Chiron Corp., Emeryville, California). See, e.g., Gretch et al. (1995) *Ann. Intern. Med.* 123:321-329. Also of interest is a nucleic acid test (NAT), developed by Gen-Probe Inc. (San Diego) and Chiron Corporation, and sold by Chiron Corporation under the trade name Procleix®, which NAT simultaneously tests for the presence of HIV-1 and HCV. See, e.g., Vargo et al. (2002) *Transfusion* 42:876-885.

[00797] In general, an effective amount of a subject agent (e.g., a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant) is an amount that is effective to reduce viral load to undetectable levels, e.g., to less than about 5000, less than about 1000, less than about 500, or less than about 200 genome copies/mL serum. In some embodiments, an effective amount of a subject agent is an amount that is effective to reduce viral load to less than 100 genome copies/mL serum. In many embodiments, the methods of the invention achieve a sustained viral response, e.g., the viral load is reduced to undetectable levels for a period of at least about one month, at least about two months, at least about three months, at least about four months, at least about five months, or at least about six months following cessation of treatment.

[00798] Whether a subject method is effective in treating an HCV infection can be determined by measuring a parameter associated with HCV infection, such as liver fibrosis. Methods of determining the extent of liver fibrosis are discussed in detail below. In some embodiments, the level of a serum marker of liver fibrosis indicates the degree of liver fibrosis.



[00799] As one non-limiting example, levels of serum alanine aminotransferase (ALT) are measured, using standard assays. In general, an ALT level of less than about 45 international units is considered normal. In some embodiments, an effective amount of a therapeutic agent that is administered as part of a subject combination therapy is an amount effective to reduce ALT levels to less than about 45 U/ml serum.

#### **Combination therapies**

[00800] In some embodiments, the present invention provides combination therapies for the treatment of a viral infection. Accordingly, the present invention provides a method of treating a viral infection, generally involving administering a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant in combination therapy with at least a second therapeutic agent. Suitable additional therapeutic agents include, but are not limited to, nucleoside analogs such as ribavirin and viramidine, L-nucleosides such as levovirin, Type II interferon receptor agonists (e.g., IFN- $\gamma$ ), TNF antagonists, thymosin- $\alpha$ , SAPK inhibitors (e.g., pirfenidone or pirfenidone analogs), amantidine, and the like. In connection with combination therapies for the treatment of HCV infection, suitable additional therapeutic agents include, but are not limited to, nucleoside analogs such as ribavirin, levovirin, and viramidine, Type II interferon receptor agonists (e.g., IFN- $\gamma$ ), TNF antagonists, NS3 inhibitors, NS5B inhibitors, alpha-glucosidase inhibitors, thymosin- $\alpha$ , SAPK inhibitors (e.g., pirfenidone or pirfenidone analogs), amantidine, and the like.

[00801] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection, e.g. HCV infection, in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00802] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection, e.g. HCV infection, in a patient can be modified to include co-administration to the patient of an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment

the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00803] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection, e.g. HCV infection, in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00804] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection, e.g. HCV infection, in a patient can be modified to include co-administration to the patient of an amount of ribavirin effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00805] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection, e.g. HCV infection, in a patient can be modified to include co-administration to the patient of an amount of an L-nucleoside (e.g., levovirin) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00806] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection, e.g. HCV infection, in a patient can be modified to include co-administration to the patient of an amount of virmidine effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00807] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a

hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection, e.g. HCV infection, in a patient can be modified to include co-administration to the patient of an amount of a TNF antagonist (e.g. etanercept, infliximab or adalimumab) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

**[00808]** As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection, e.g. HCV infection, in a patient can be modified to include co-administration to the patient of an amount of thymosin- $\alpha$  effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

**[00809]** As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS3 inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

**[00810]** As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS5B inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

**[00811]** As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an alpha-glucosidase inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

- [00812] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.
- [00813] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of a nucleoside analog effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.
- [00814] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of ribavirin effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.
- [00815] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of an L-nucleoside (e.g., levovirin) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.
- [00816] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide

agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of viramidine effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00817] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00818] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of thymosin- $\alpha$  effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00819] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of an NS3 inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00820] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$

and an amount of an NS5B inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00821] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of IFN- $\gamma$  and an amount of an alpha-glucosidase inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00822] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viramidine, or an L-nucleoside such as levovirin) and an amount of IFN- $\gamma$  effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00823] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viramidine, or an L-nucleoside such as levovirin) and an amount of TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00824] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viramidine, or an L-nucleoside such as levovirin) and an amount of thymosin- $\alpha$  effective to augment the anti-viral effect of the

synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00825] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of viral infection (e.g., HCV infection) in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viramidine, or an L-nucleoside such as levovirin) and an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00826] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viramidine, or an L-nucleoside such as levovirin) and an amount of an NS3 inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00827] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viramidine, or an L-nucleoside such as levovirin) and an amount of an NS5B inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00828] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viramidine, or an L-nucleoside such as levovirin) and an amount of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment

the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00829] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS3 inhibitor and an amount of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00830] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS5B inhibitor and an amount of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00831] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an alpha-glucosidase inhibitor and an amount of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00832] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfendione analog) and an amount of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment the anti-viral effect of the



synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00833] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of thymosin- $\alpha$  and an amount of a TNF antagonist (e.g., etanercept, infliximab, or adalimumab) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00834] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viramidine, or an L-nucleoside such as levovirin) and an amount of thymosin- $\alpha$  effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00835] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) and an amount of thymosin- $\alpha$  effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00836] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS3 inhibitor and an amount of thymosin- $\alpha$  effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00837] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS5B inhibitor and an amount of thymosin- $\alpha$  effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00838] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an alpha-glucosidase inhibitor and an amount of thymosin- $\alpha$  effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00839] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viremide, or an L-nucleoside such as levovirin) and an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00840] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS3 inhibitor and an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00841] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS5B inhibitor and an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00842] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an alpha-glucosidase inhibitor and an amount of a SAPK inhibitor (e.g., pirfenidone or a pirfenidone analog) effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00843] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of a nucleoside analog (e.g., ribavirin, viramidine, or an L-nucleoside such as levovirin) and an amount of an alpha-glucosidase inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00844] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS5B inhibitor and an amount of an NS3 inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00845] " " As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist, a hyperglycosylated polypeptide variant, a protease-resistant polypeptide variant, or a hyperglycosylated, protease-resistant polypeptide variant for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an alpha-glucosidase inhibitor and an amount of an NS3 inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

[00846] As non-limiting examples, any of the above-described treatment methods featuring therapy with an effective amount of a subject synthetic Type I interferon receptor polypeptide agonist for the treatment of an HCV infection in a patient can be modified to include co-administration to the patient of an amount of an NS5B inhibitor and an amount of an alpha-glucosidase inhibitor effective to augment the anti-viral effect of the synthetic Type I interferon receptor polypeptide agonist therapy, for the desired treatment duration.

*Patient Identification*

[00847] In certain embodiments, the specific regimen of drug therapy used in treatment of the HCV patient is selected according to certain disease parameters exhibited by the patient, such as the initial viral load, genotype of the HCV infection in the patient, liver histology and/or stage of liver fibrosis in the patient.

[00848] Thus, in some embodiments, the present invention provides any of the above-described methods for the treatment of HCV infection in which the subject method is modified to treat a treatment failure patient for a duration of 48 weeks.

[00849] In other embodiments, the invention provides any of the above-described methods for HCV in which the subject method is modified to treat a non-responder patient, where the patient receives a 48 week course of therapy.

[00850] In other embodiments, the invention provides any of the above-described methods for the treatment of HCV infection in which the subject method is modified to treat a relapser patient, where the patient receives a 48 week course of therapy.

[00851] In other embodiments, the invention provides any of the above-described methods for the treatment of HCV infection in which the subject method is modified to treat a naïve patient infected with HCV genotype 1, where the patient receives a 48 week course of therapy.

[00852] In other embodiments, the invention provides any of the above-described methods for the treatment of HCV infection in which the subject method is modified to treat a naïve patient infected with HCV genotype 4, where the patient receives a 48 week course of therapy.

[00853] In other embodiments, the invention provides any of the above-described methods for the treatment of HCV infection in which the subject method is modified to treat a naïve patient infected with HCV genotype 1, where the patient has a high viral load (HVL), where “HVL” refers to an HCV viral load of greater than  $2 \times 10^6$  HCV genome copies per mL serum, and where the patient receives a 48 week course of therapy.

[00854] In one embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having advanced or severe stage liver fibrosis as measured by a Knodell score of 3 or 4 and then (2) administering to the patient the drug therapy of the subject method for a time period of about 24 weeks to about 60 weeks, or about 30 weeks to about one year, or about 36 weeks to about 50 weeks, or about 40 weeks to about 48 weeks, or at least about 24 weeks, or at least about 30 weeks, or at least about 36 weeks, or at least about 40 weeks, or at least about 48 weeks, or at least about 60 weeks.

[00855] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having advanced or severe stage liver fibrosis as measured by a Knodell score of 3 or 4 and then (2) administering to the patient the drug therapy of the subject method for a time period of about 40 weeks to about 50 weeks, or about 48 weeks.

[00856] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 1 infection and an initial viral load of greater than 2 million viral genome copies per ml of patient serum and then (2) administering to the patient the drug therapy of the subject method for a time period of about 24 weeks to about 60 weeks, or about 30 weeks to about one year, or about 36 weeks to about 50 weeks, or about 40 weeks to about 48 weeks, or at least about 24 weeks, or at least about 30 weeks, or at least about 36 weeks, or at least about 40 weeks, or at least about 48 weeks, or at least about 60 weeks.

[00857] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 1 infection and an initial viral load of greater than 2 million viral genome copies per ml of patient serum and then (2) administering to the patient the drug therapy of the subject method for a time period of about 40 weeks to about 50 weeks, or about 48 weeks.

[00858] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 1 infection and an initial viral load of greater than 2 million viral genome copies per ml of patient serum and no or early stage liver fibrosis as measured by a Knodell score of 0, 1, or 2 and then (2) administering to the patient the drug therapy of the subject method for a time period of about 24 weeks to about 60 weeks, or about 30 weeks to about one year, or about 36 weeks to about 50 weeks, or about 40 weeks to about 48 weeks, or at least about 24 weeks, or at least about 30 weeks, or at least about 36 weeks, or at least about 40 weeks, or at least about 48 weeks, or at least about 60 weeks.

[00859] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 1 infection and an initial viral load of greater than 2 million viral genome copies per ml of patient serum and no or early stage liver fibrosis as measured by a Knodell score of 0, 1, or 2 and then (2) administering to the patient the drug therapy of the subject method for a time period of about 40 weeks to about 50 weeks, or about 48 weeks.

[00860] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 1 infection and an initial viral load of less than or equal to 2 million viral genome copies per ml of patient serum and then (2) administering to the patient the drug therapy of the subject method for a time period of about 20 weeks to about 50 weeks, or about 24 weeks to about 48 weeks, or about 30 weeks to about 40 weeks, or up to about 20 weeks, or up to about 24 weeks, or up to about 30 weeks, or up to about 36 weeks, or up to about 48 weeks.

[00861] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 1 infection and an initial viral load of less than or equal to 2 million viral genome copies per ml of patient serum and then (2) administering to the patient the drug therapy of the subject method for a time period of about 20 weeks to about 24 weeks.

[00862] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 1 infection and an initial viral load of less than or equal to 2 million viral genome copies per ml of patient serum and then (2)

administering to the patient the drug therapy of the subject method for a time period of about 24 weeks to about 48 weeks.

[00863] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 2 or 3 infection and then (2) administering to the patient the drug therapy of the subject method for a time period of about 24 weeks to about 60 weeks, or about 30 weeks to about one year, or about 36 weeks to about 50 weeks, or about 40 weeks to about 48 weeks, or at least about 24 weeks, or at least about 30 weeks, or at least about 36 weeks, or at least about 40 weeks, or at least about 48 weeks, or at least about 60 weeks.

[00864] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 2 or 3 infection and then (2) administering to the patient the drug therapy of the subject method for a time period of about 20 weeks to about 50 weeks, or about 24 weeks to about 48 weeks, or about 30 weeks to about 40 weeks, or up to about 20 weeks, or up to about 24 weeks, or up to about 30 weeks, or up to about 36 weeks, or up to about 48 weeks.

[00865] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 2 or 3 infection and then (2) administering to the patient the drug therapy of the subject method for a time period of about 20 weeks to about 24 weeks.

[00866] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 2 or 3 infection and then (2) administering to the patient the drug therapy of the subject method for a time period of at least about 24 weeks.

[00867] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV genotype 1 or 4 infection and then (2) administering to the patient the drug therapy of the subject method for a time period of about 24 weeks to about 60 weeks, or about 30 weeks to about one year, or about 36 weeks to about 50 weeks, or about 40 weeks to about 48 weeks, or at least about 24 weeks, or at least about 30 weeks, or at

least about 36 weeks, or at least about 40 weeks, or at least about 48 weeks, or at least about 60 weeks.

[00868] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV infection characterized by any of HCV genotypes 5, 6, 7, 8 and 9 and then (2) administering to the patient the drug therapy of the subject method for a time period of about 20 weeks to about 50 weeks.

[00869] In another embodiment, the invention provides any of the above-described methods for the treatment of an HCV infection, where the subject method is modified to include the steps of (1) identifying a patient having an HCV infection characterized by any of HCV genotypes 5, 6, 7, 8 and 9 and then (2) administering to the patient the drug therapy of the subject method for a time period of at least about 24 weeks and up to about 48 weeks.

#### **Type II interferon receptor agonists**

[00870] As used herein, the term "Type II interferon receptor agonist" includes any naturally occurring or non-naturally-occurring ligand of a human Type II interferon receptor that binds to and causes signal transduction via the receptor. Type II interferon receptor agonists include interferons, including naturally-occurring interferons, modified interferons, synthetic interferons, pegylated interferons, fusion proteins comprising an interferon and a heterologous protein, shuffled interferons; antibody specific for an interferon receptor; non-peptide chemical agonists; and the like.

[00871] A specific example of a Type II interferon receptor agonist is IFN-gamma and variants thereof. While the present invention exemplifies use of an IFN-gamma polypeptide, it will be readily apparent that any Type II interferon receptor agonist can be used in a subject method.

#### **SAPK Inhibitors**

[00872] SAPK inhibitors suitable for use in a subject treatment method specifically include pirfenidone and pirfenidone analogs; and also specifically include any compound of Formula I as set forth in U.S. Patent Publication No. 20030149041.

[00873] Additional SAPK inhibitors suitable for use herein include agents that inhibit enzymatic activity of a SAPK by at least about 10%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, or at least about 90%, or more, when compared with the enzymatic activity of the SAPK in the absence of the SAPK inhibitor.

[00874] The signal transduction pathways that use mitogen-activated protein kinases (MAPK) have an important role in a variety of cellular responses, including growth, stress-induced gene



expression, and compensation for alterations in the environment. The SAPK group of MAPKs includes the c-Jun N-terminal Kinase (JNK) and p38 kinases. The p38 group of MAPK include at least four members, designated p38 or p38 $\alpha$ , p38 $\beta$ , p38 $\gamma$ , and p38 $\delta$ . The amino acid sequences of p38 $\alpha$ , p38 $\beta$ , and p38 $\gamma$  from various species are known. For example, the amino acid sequences of human p38 $\alpha$ , p38 $\beta$ , and p38 $\gamma$  are found under the following GenBank Accession Nos.: 1) Q16539, NP\_620583, and NP\_001306 provide amino acid sequences of human p38 $\alpha$  polypeptides; 2) NP\_620478, NP\_002742, and Q15759 provide amino acid sequences of human p38 $\beta$  polypeptides; and 3) NP\_002960, P53778, and JC5252 provide amino acid sequences of human p38 $\gamma$  polypeptides.

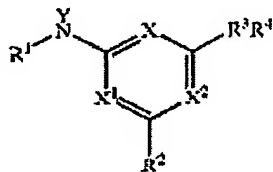
[00875] In some embodiments, a suitable SAPK inhibitor is an agent that inhibits enzymatic activity of p38 $\alpha$ , p38 $\beta$ , and p38 $\gamma$ . In other embodiments, a suitable SAPK inhibitor is an agent that preferentially inhibits the enzymatic activity of p38 $\alpha$  and p38 $\beta$ , i.e., the agent is a stronger inhibitor of the enzymatic activity of p38 $\alpha$  and p38 $\beta$  than that of p38 $\gamma$ , e.g., the agent's IC<sub>50</sub> against p38 $\alpha$  and p38 $\beta$  is at least about two-fold lower, or about five-fold lower, or about ten-fold lower, or more, below the agent's IC<sub>50</sub> against p38 $\gamma$ .

[00876] In other embodiments, a suitable SAPK inhibitor is an agent that preferentially inhibits p38 $\gamma$ , i.e., the agent is a stronger inhibitor of the enzymatic activity of p38 $\gamma$  than that of p38 $\alpha$  and p38 $\beta$ , e.g., the agent's IC<sub>50</sub> against p38 $\gamma$  is at least about two-fold lower, or about five-fold lower, or about ten-fold lower, or more, below the agent's IC<sub>50</sub> against p38 $\alpha$  and p38 $\beta$ .

[00877] In some embodiments, a SAPK inhibitor is a competitive inhibitor of a SAPK, e.g., a p38 $\alpha$ , a p38 $\beta$ , or a p38 $\gamma$ . In some of these embodiments, a SAPK inhibitor is one that competes for adenosine triphosphate (ATP) for binding to the ATP binding site of p38 $\alpha$ , p38 $\beta$ , or p38 $\gamma$ .

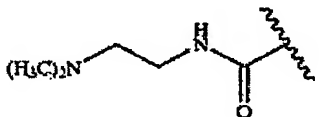
[00878] In addition, stress-activated protein kinase (SAPK) inhibitors that are suitable for use in a subject combination therapy include any 2-alkyl imidazole as disclosed in U.S. Patent No. 6,548,520; any of the 1,4,5-substituted imidazole compounds disclosed in U.S. Patent No. 6,489,325; 1,4,5-substituted imidazole compounds disclosed in U.S. Patent No. 6,569,871; heteroaryl aminophenyl ketone compounds disclosed in Published U.S. Patent Application No. 2003/0073832; pyridyl imidazole compounds disclosed in U.S. Patent No. 6,288,089; and heteroaryl aminobenzophenones disclosed in U.S. Patent No. 6,432,962. Also suitable for use are compounds disclosed in U.S. Patent No. 6,214,854. Also suitable for use are the heterocyclic compounds discussed in WO 99/61426.

[00879] Pirfenidone and pirfenidone analogs, which are specifically included, are described in detail below. As discussed above, compounds of Formula I of U.S. Patent Publication No. 20030149041 are specifically included. Formula I is as follows:

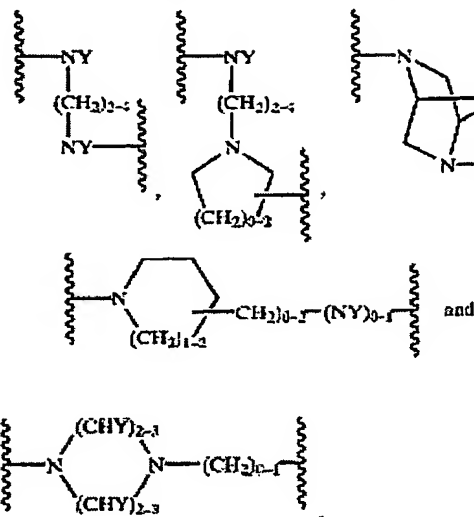


Formula I (20030149041)

- [00880] wherein:  $R^1$  is chosen from --H,  $C_1$  to  $C_{20}$  hydrocarbon, aminocarbonylalkyl, alkoxyalkyl, substituted arylalkyl, heteroaryl, heteroarylalkyl, heterocyclalkyl, and substituted heterocyclalkyl;
- [00881]  $R^2$  is chosen from halogen,  $C_1$  to  $C_{20}$  hydrocarbon, hydroxy, heteroaryl, substituted heteroaryl, heterocycl, substituted heterocycl;
- [00882]  $R^5$  is chosen from --H, alkyl and substituted alkyl;
- [00883]  $R^6$  is chosen from a direct bond, alkyl, aryl, substituted aryl and heteroaryl;
- [00884]  $R^7$  is chosen from --H, acyl, alkyl, substituted alkyl, alkoxycarbonyl, amidine, aryl, arylalkyl, heterocycl, heteroaryl, substituted heteroaryl, substituted aryloxy, heteroarylsulfonamido, dialkylsulfonamido,

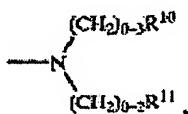


- [00885] --C(O)NR<sup>8</sup>R<sup>9</sup>, --C(NH)NR<sup>8</sup>R<sup>9</sup> and --NR<sup>8</sup>R<sup>9</sup>;
- [00886]  $R^8$  is chosen from --H and alkyl;
- [00887]  $R^9$  is chosen from --H, alkyl, substituted alkyl, aryl, heteroaryl, alkylcarbonyl and arylcarbonyl;
- [00888]  $R^3$  is chosen from a direct bond,

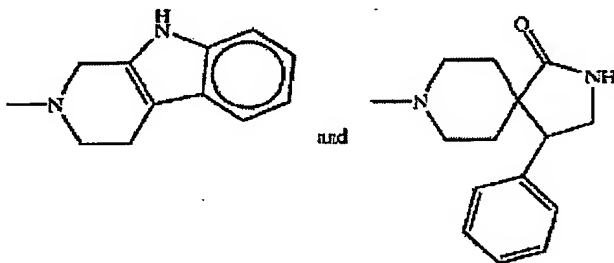


[00889] wherein the left hand bond is the point of attachment to the ring and the right hand bond is the point of attachment to  $R^4$ ;

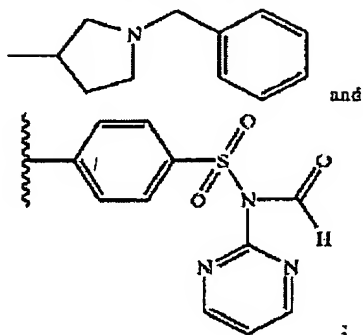
[00890] R<sup>4</sup> is chosen from --H, halogen, alkyl, heterocyclyl, alkylamino, aminocarbonyl,



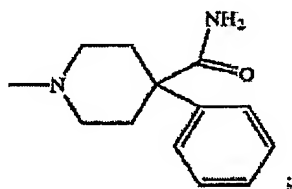
[00891]  $--C(S)NHR^{12}$ ,  $--CHR^{13}R^{14}$ ,  $--C(O)NHR^{15}$ ,  $--C(O)(CH_2)_{0-2}R^{16}$ ,  $--S(O_2)R^{17}$ ,  $--OR^{18}$



[00892] wherein R<sup>10</sup> is chosen from --H, --OH, alkyl, cycloalkyl and substituted cycloalkyl; R<sup>11</sup> is chosen from --H, --OH, --COOH, aryl, substituted aryl, heteroaryl, substituted heteroaryl, aryl substituted alkyl, cycloalkyl, substituted cycloalkyl, alkoxy, aminocarbonyl, aminocarbonylalkyl,

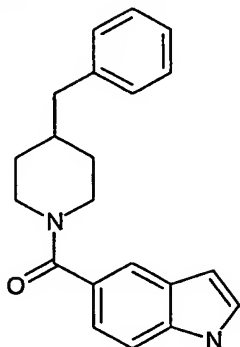


[00893]  $R^{12}$  is chosen from alkyl and aryl;  $R^{13}$  is chosen from --H and aryl;  $R^{14}$  is chosen from aryl, substituted aryl, heteroaryl, substituted alkyl, aryl substituted alkyl and alkoxy substituted alkyl;  $R^{15}$  is chosen from alkyl, aryl, substituted aryl and substituted alkyl;  $R^{16}$  is chosen from aryl, substituted aryl, heteroaryl, carboxyl, alkoxy, substituted alkyl, cycloalkyl, substituted cycloalkyl, aminocarbonyl, substituted aminocarbonyl, heterocyclyl and



[00894]  $R^{17}$  is chosen from alkyl and dialkylamino;  $R^{18}$  is chosen from  $C_1$  to  $C_{20}$  hydrocarbon, substituted  $C_1$  to  $C_{20}$  hydrocarbon and heteroaryl; Y is chosen from --H and lower alkyl, or Y and  $R^1$  taken together with the attached N, may be chosen from heterocyclyl, substituted heterocyclyl, heteroaryl and substituted heteroaryl; wherein at least two of X,  $X^1$  and  $X^2$  are --N=, and the other is chosen from --C(H)= and --N=.

[00895] Of particular interest in some embodiments is use of any of the following SAPK inhibitor compounds, or pharmaceutically acceptable salts, or derivatives, or esters, or analogs, thereof:

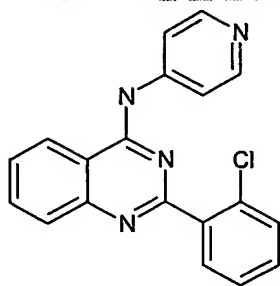


[00896] which compound has the IUPAC designation (4-benzyl-piperidin-1-yl)-(1H-indol-5-yl)-methanone. Also suitable for use are any of the following compounds: (4-benzyl-piperidin-1-yl)-(6-chloro-1H-indol-5-yl)-methanone; (4-chloro-1H-indol-5-yl)-[4-(4-fluoro-benzyl)-piperidin-1-yl]-methanone; (4-benzyl-piperidin-1-yl)-(4-methoxy-1H-indol-5-yl)-methanone; (4-Benzyl-piperidin-1-yl)-{1-[3-(cyclohexylmethyl-amino)-2-hydroxy-propyl]-1H-indol-5-yl}-methanone; (4-Benzyl-piperidin-1-yl)-{1-[2-hydroxy-3-(4-methyl-piperazin-1-yl)-propyl]-1H-indol-5-yl}-methanone; [1-(3-Benzylamino-2-hydroxy-propyl)-1H-indol-5-yl]-(4-benzyl-piperidin-1-yl)-methanone; (4-Benzyl-piperidin-1-yl)-{1-[2-hydroxy-3-(4-methoxy-benzylamino)-propyl]-1H-indol-5-yl}-methanone; (4-Benzyl-piperidin-1-yl)-[1-(2-hydroxy-3-propylamino-propyl)-1H-indol-5-yl]-methanone; (4-Benzyl-piperidin-1-yl)-[1-(pyridine-4-carbonyl)-1H-indol-5-yl]-methanone; 1-[5-(4-Benzyl-piperidine-1-carbonyl)-indol-1-yl]-ethanone; 2-[5-(4-Benzyl-piperidine-1-carbonyl)-indol-1-yl]-N-(4-methoxy-benzyl)-acetamide; 5-(4-Benzyl-piperidine-1-carbonyl)-1H-indole-3-carboxylic acid (2-methoxy-ethyl)-amide; 5-(4-Benzyl-piperidine-1-carbonyl)-1H-indole-3-carboxylic acid (2-methylamino-ethyl)-amide; 5-(4-Benzyl-piperidine-1-carbonyl)-1H-indole-3-carboxylic acid (2-amino-ethyl)-amide; [3-(4-Benzyl-piperidine-1-carbonyl)-1H-indol-5-yl]-(4-benzyl-piperidin-1-yl)-methanone; [3-(4-Benzyl-piperidine-1-carbonyl)-1H-indol-6-yl]-(4-benzyl-piperidin-1-yl)-methanone; 5-(4-Benzyl-piperidine-1-carbonyl)-1H-indole-3-carboxylic acid 4-fluoro-benzylamide; 5-(4-Benzyl-piperidine-1-carbonyl)-1H-indole-3-carboxylic acid [2-(3,5-dimethoxy-phenyl)-ethyl]-amide; (4-Benzyl-piperidin-1-yl)-(6-methoxy-1H-indol-5-yl)-methanone; 1-[5-(4-Benzyl-piperidine-1-carbonyl)-1H-indol-3-yl]-2,2,2-trifluoro-ethanone; 5-(4-Benzyl-piperidine-1-carbonyl)-6-methoxy-1H-indole-3-carboxylic acid (2-dimethylamino-ethyl)-amide; 5-(4-Benzyl-piperidine-1-carbonyl)-1H-indole-3-carboxylic acid; 5-(4-Benzyl-piperidine-1-carbonyl)-1H-indole-3-carboxylic acid (2-dimethylamino-ethyl)-amide; (1H-Benzoimidazol-5-yl)-(4-benzyl-piperidin-1-yl)-methanone; (1H-Benzoimidazol-5-yl)-[4-(4-fluoro-benzyl)-piperidin-1-yl]-methanone; (4-Benzyl-piperidin-1-yl)-(3-morpholin-4-ylmethyl-

1H-indol-5-yl)-methanone; 1-[6-(4-Benzyl-piperidine-1-carbonyl)-1H-indol-3-yl]-2,2,2-trifluoro-ethanone; (4-Benzyl-piperidin-1-yl)-[1-(pyridine-4-carbonyl)-1H-indol-6-yl]-methanone; (3-Benzyl-8-aza-bicyclo[3.2.1]oct-8-yl)-(6-methoxy-1H-indol-5-yl)-methanone; (3H-Benzoimidazol-5-yl)-(3-benzyl-8-aza-bicyclo[3.2.1]oct-8-yl)-methanone; [3-(4-Fluorobenzyl)-pyrrolidin-1-yl]-(1H-indol-6-yl)-methanone; (1H-Benzoimidazol-5-yl)-[4-(2,6-difluoro-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(4-methylsulfanylbenzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(2,3-difluoro-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(3,5-difluoro-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(3-chloro-benzyl)-piperazin-1-yl]-methanone; 4-[4-(1H-Benzoimidazole-5-carbonyl)-piperazin-1-ylmethyl]-benzoic acid methyl ester; (1H-Benzoimidazol-5-yl)-[4-(4-methoxy-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(4-trifluoromethoxy-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(4-methyl-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(2,4-dichlorobenzoyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(3,4-dichlorobenzoyl)-piperazin-1-yl]-methanone; trans-1-[4-(1H-Benzoimidazole-5-carbonyl)-piperazin-1-yl]-3-(3-trifluoromethyl-phenyl)-propenone; (1H-Benzoimidazol-5-yl)-[4-(4-chloro-benzoyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-(4-benzoyl-piperazin-1-yl)-methanone; (1H-Benzoimidazol-5-yl)-[4-(2-trifluoromethyl-benzoyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(4-methoxy-benzoyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(3,4-dichloro-phenyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-{4-[(4-chloro-phenyl)-phenyl-methyl]-piperazin-1-yl}-methanone; trans-(1H-Benzoimidazol-5-yl)-[4-(3-phenyl-allyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-{4-[bis-(4-fluorophenyl)-methyl]-piperazin-1-yl}-methanone; (1H-Benzoimidazol-5-yl)-[4-(4-chloro-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(2-chloro-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(3,4,5-trimethoxy-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-[4-(4-diethylamino-benzyl)-piperazin-1-yl]-methanone; (1H-Benzoimidazol-5-yl)-(4-biphenyl-4-ylmethyl-piperazin-1-yl)-methanone; (1H-Benzoimidazol-5-yl)-[4-(4-phenoxy-benzyl)-piperazin-1-yl]-methanone; (4-Benzyl-piperidin-1-yl)-(6-methoxy-1H-benzoimidazol-5-yl)-methanone; (4-Benzyl-piperidin-1-yl)-(1-isopropyl-1H-benzoimidazol-5-yl)-methanone; (4-Benzyl-piperidin-1-yl)-(3-isopropyl-3H-benzoimidazol-5-yl)-methanone; (4-Benzyl-piperidin-1-yl)-(1-isopropyl-1H-indol-5-yl)-methanone; [4-(4-Chloro-benzyl)-piperazin-1-yl]-(1-isopropyl-1H-indol-5-yl)-methanone; (1H-Benzotriazol-5-yl)-(4-benzyl-piperidin-1-yl)-methanone; (4-Benzyl-piperidin-1-yl)-(1-isopropyl-1H-benzotriazol-5-yl)-methanone; [4-(4-Chloro-benzyl)-piperidin-1-yl]-(1H-indol-

5-yl)-methanone; [4-(3-Chloro-benzyl)-piperidin-1-yl]-(1H-indol-5-yl)-methanone; [4-(2-Chloro-benzyl)-piperidin-1-yl]-(1H-indol-5-yl)-methanone; (4-Benzyl-2-methyl-piperidin-1-yl)-(1H-indol-5-yl)-methanone; (4-Benzyl-piperidin-1-yl)-(4-chloro-1H-indol-5-yl)-methanone; (4-Benzyl-piperidin-1-yl)-[7-chloro-1-(pyridine-3-carbonyl)-1H-indol-6-yl]-methanone; (4-Benzyl-piperidin-1-yl)-(5-chloro-1H-indol-6-yl)-methanone; (4-Benzyl-piperidin-1-yl)-(7-chloro-1H-indol-6-yl)-methanone; 6-(4-Benzyl-piperidine-1-carbonyl)-7-chloro-1-(pyridine-3-carbonyl)-1H-indole-3-carboxylic acid (2-dimethylamino-ethyl)-amide; (4-Benzyl-piperidin-1-yl)-(1-pyridin-4-ylmethyl-1H-indol-5-yl)-methanone; (4-Benzyl-piperidin-1-yl)-[6-methoxy-1-(pyridine-3-carbonyl)-1H-indol-5-yl]-methanone; [5-(4-Benzyl-piperidine-1-carbonyl)-indol-1-yl]-acetic acid methyl ester; 1-[5-(4-Benzyl-piperidine-1-carbonyl)-indol-1-yl]-3-isopropylamino-propan-1-one; 1-[5-(4-Benzyl-piperidine-1-carbonyl)-indol-1-yl]-3-piperazin-1-yl-propan-1-one; 3-Benzylamino-1-[5-(4-benzyl-piperidine-1-carbonyl)-indol-1-yl]-propan-1-one; 1-[5-(4-Benzyl-piperidine-1-carbonyl)-indol-1-yl]-3-morpholin-4-yl-propan-1-one; 2-[5-(4-Benzyl-piperidine-1-carbonyl)-indol-1-yl]-N-propyl-acetamide; (4-Benzyl-piperidin-1-yl)-[1-(2-diethylamino-ethyl)-6-methoxy-1H-indol-5-yl]-methanone; (4-Benzyl-piperidin-1-yl)-[1-(3-diethylamino-propyl)-1H-indol-5-yl]-methanone; (4-Benzyl-piperidin-1-yl)-[1-(2-diethylamino-ethyl)-1H-indol-5-yl]-methanone; (4-Benzyl-piperidin-1-yl)-[6-chloro-1-(3-diethylamino-propyl)-1H-indol-5-yl]-methanone; [1-(2-Diethylamino-ethyl)-1H-indol-5-yl]-[4-(4-fluoro-benzyl)-piperidin-1-yl]-methanone; (4-Benzyl-piperidin-1-yl)-[1-(3-diethylamino-propyl)-6-methoxy-1H-indol-5-yl]-methanone; 5-(4-Benzyl-piperidine-1-carbonyl)-1H-indole-3-carboxylic acid (2-amino-ethyl)-methyl-amide; 5-(4-Benzyl-piperidine-1-carbonyl)-1H-indole-3-carboxylic acid [2-(3,4-dimethoxy-phenyl)-ethyl]-amide; (4-Benzyl-piperidin-1-yl)-(3-diethylaminomethyl-1H-indol-5-yl)-methanone; [4-(4-Fluoro-benzyl)-piperidin-1-yl]-(6-methoxy-1H-indol-5-yl)-methanone; (4-Benzyl-piperidin-1-yl)-(1-pyridin-4-yl-1H-indol-5-yl)-methanone; and 4(4-Benzyl-piperidin-1-yl)-(4-chloro-2-methyl-1H-indol-5-yl)-methanone; or pharmaceutically acceptable salts, or derivatives, or esters, or analogs, of any of the foregoing compounds.

[00897] Of particular interest in some embodiments is use of any of the following SAPK inhibitor compounds, or pharmaceutically acceptable salts, or derivatives, or esters, or analogs, thereof:



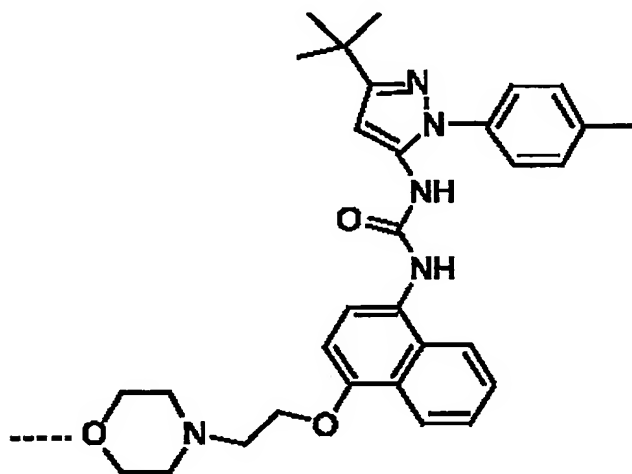
[00898] which compound has the IUPAC designation '2-(2-Chloro-phenyl)-quinazolin-4-yl]-pyridin-4-yl-amine. Also suitable for use are any of the following compounds: [2-(2,6-Dichloro-phenyl)-quinazolin-4-yl]-pyridin-4-yl-amine; Pyridin-4-yl-(2-o-tolyl-quinazolin-4-yl)-amine; [2-(2-Bromo-phenyl)-quinazolin-4-yl]-pyridin-4-yl-amine; [2-(2-Fluoro-phenyl)-quinazolin-4-yl]-pyridin-4-yl-amine; [2-(2,6-Difluoro-phenyl)-quinazolin-4-yl]-pyridin-4-yl-amine; (2-Phenyl-quinazolin-4-yl)-pyridin-4-yl-amine; [2-(4-Fluoro-phenyl)-quinazolin-4-yl]-pyridin-4-yl-amine; [2-(4-Methoxy-phenyl)-quinazolin-4-yl]-pyridin-4-yl-amine; [2-(3-Fluoro-phenyl)-quinazolin-4-yl]-pyridin-4-yl-amine; Isopropyl-(2-phenyl-quinazolin-4-yl)-pyridin-4-yl-amine; (4-Methoxy-benzyl)-(2-phenyl-quinazolin-4-yl)-pyridin-4-yl-amine; (2-Phenyl-quinazolin-4-yl)-pyridin-4-ylmethyl-amine; [2-(4-Chloro-phenyl)-quinazolin-4-yl]-pyridin-4-ylmethyl-amine; (2-Phenyl-quinazolin-4-yl)-pyridin-3-yl-amine; (2-Phenyl-quinazolin-4-yl)-pyridin-2-ylmethyl-amine; (2-Phenyl-quinazolin-4-yl)-pyridin-3-ylmethyl-amine; (2-Phenyl-quinazolin-4-yl)-(2-pyridin-2-yl-ethyl)-amine; (2-Phenyl-quinazolin-4-yl)-pyrimidin-4-yl-amine; (2-Phenyl-quinazolin-4-yl)-pyrimidin-2-yl-amine; Phenyl-(2-phenyl-quinazolin-4-yl)-amine; Benzyl-[2-(3-chloro-phenyl)-quinazolin-4-yl]-amine; 3-(2-Phenyl-quinazolin-4-ylamino)-phenol; 2-(2-Phenyl-quinazolin-4-ylamino)-phenol; 4-(2-Phenyl-quinazolin-4-ylamino)-phenol; (1H-Indol-4-yl)-(2-phenyl-quinazolin-4-yl)-amine; (1H-Indol-5-yl)-(2-phenyl-quinazolin-4-yl)-amine; (4-Methoxy-phenyl)-(2-phenyl-quinazolin-4-yl)-amine; (3-Methoxy-phenyl)-(2-phenyl-quinazolin-4-yl)-amine; (2-Methoxy-phenyl)-(2-phenyl-quinazolin-4-yl)-amine; 2-[4-(2-Phenyl-quinazolin-4-ylamino)-phenyl]-ethanol; 3-(2-Phenyl-quinazolin-4-ylamino)-benzonitrile; (2,5-Difluoro-benzyl)-(2-phenyl-quinazolin-4-yl)-amine; [4-(2-Butyl)-phenyl]-(2-phenyl-quinazolin-4-yl)-amine; N,N-Dimethyl-N'-(2-phenyl-quinazolin-4-yl)-benzene-1,4-diamine; [2-(2-Chloro-phenyl)-6,7-dimethoxy-quinazolin-4-yl]-pyridin-4-yl-amine; [2-(2-Fluoro-phenyl)-6-nitro-quinazolin-4-yl]-pyridin-4-yl-amine; 2-(2-Fluoro-phenyl)-N4-pyridin-4-yl-quinazoline-4,6-diamine; 2-(2-Fluoro-phenyl)-N4-pyridin-4-yl-quinazoline-4,7-diamine; 2-(2-Fluoro-phenyl)-N6-(3-methoxy-benzyl)-N4-pyridin-4-yl-quinazoline-4,6-diamine; 2-(2-Fluoro-phenyl)-N6-(4-methoxy-benzyl)-N4-pyridin-4-yl-quinazoline-4,6-diamine; N6-Isobutyl-2-(2-fluoro-phenyl)-N4-pyridin-4-yl-quinazoline-4,6-



diamine; 2-(2-Fluoro-phenyl)-N6-(4-methylsulfonyl-benzyl)-N4-pyridin-4-yl-quinazoline-4,6-diamine; 4-(4-Pyridylamino)-2-(4-chlorophenyl)quinazoline; 2-Phenyl-4-(2-pyridylamino)-quinazoline; and [2-(2-Fluoro-phenyl)-pyrido[2,3-d]pyrimidin-4-yl]-pyridin-4-yl-amine; or pharmaceutically acceptable salts, or derivatives, or esters, or analogs, of any of the foregoing compounds.

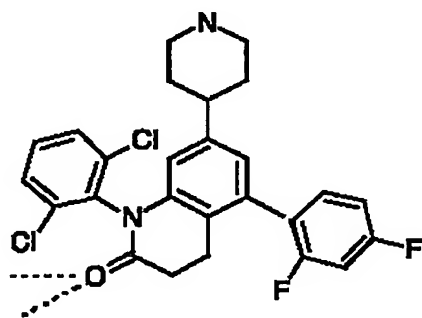
[00899] A further suitable SAPK inhibitor is BIRB796 (1-(5-tert-butyl-2-p-tolyl-2H-pyrazol-3-yl)-3-[4-(2-morpholin-4-yl-ethoxy)-naphthalen-1-yl]-urea); see U.S. Patent no. 6,319,921.

[00900] BIRB796 has the following structure:



[00901] Also suitable for use are pharmaceutically active derivatives, analogs, esters, and salts of BIRB796.

[00902] Another suitable SAPK inhibitor is 2(1H)-quinazolinone, as shown below:



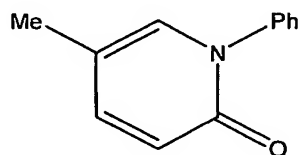
[00903] Also suitable for use are pharmaceutically active derivatives, analogs, esters, and salts of 2(1H)-quinazolinone.

[00904] Additionally suitable for use is VX-745 (Vertex Pharmaceuticals and Kissei Pharmaceutical Co.) VX-745 has been reported to inhibit several isoforms of p38, including p38-alpha, p38-beta and p38-gamma.

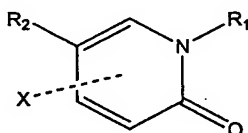
## Pirfenidone and Analogs Thereof

[00905] Pirfenidone (5-methyl-1-phenyl-2-(1H)-pyridone) and specific pirfenidone analogs can be used to enhance the methods of treatment for HCV infection disclosed herein.

### Pirfenidone

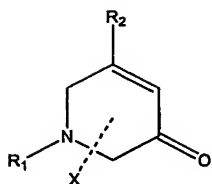


### Pirfenidone analogs

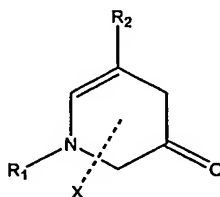


I.

II.A



II.B



### Descriptions for Substituents R<sub>1</sub>, R<sub>2</sub>, X

[00906] R<sub>1</sub>: carbocyclic (saturated and unsaturated), heterocyclic (saturated or unsaturated), alkyls (saturated and unsaturated). Examples include phenyl, benzyl, pyrimidyl, naphthyl, indolyl, pyrrolyl, furyl, thienyl, imidazolyl, cyclohexyl, piperidyl, pyrrolidyl, morpholinyl, cyclohexenyl, butadienyl, and the like.

[00907] R<sub>1</sub> can further include substitutions on the carbocyclic or heterocyclic moieties with substituents such as halogen, nitro, amino, hydroxyl, alkoxy, carboxyl, cyano, thio, alkyl, aryl, heteroalkyl, heteroaryl and combinations thereof, for example, 4-nitrophenyl, 3-chlorophenyl, 2,5-dinitrophenyl, 4-methoxyphenyl, 5-methyl-pyrrolyl, 2, 5-dichlorocyclohexyl, guanidinyl-cyclohexenyl and the like.

[00908] R<sub>2</sub>: alkyl, carbocyclic, aryl, heterocyclic, hydroxyl, alkoxy, carboxyl. Examples include: methyl, ethyl, propyl, isopropyl, phenyl, 4-nitrophenyl, thienyl, hydroxyl, methoxy, carboxy and the like.

[00909] **X:** may be any number (from 1 to 3) of substituents on the carbocyclic or heterocyclic ring. The substituents can be the same or different. Substituents can include hydrogen, alkyl, heteroalkyl, aryl, heteroaryl, halo, nitro, carboxyl, hydroxyl, cyano, amino, thio, alkylamino, haloaryl and the like.

[00910] The substituents may be optionally further substituted with 1-3 substituents from the group consisting of alkyl, aryl, nitro, alkoxy, hydroxyl and halo groups. Examples include: methyl, 2,3-dimethyl, phenyl, p-tolyl, 4-chlorophenyl, 4-nitrophenyl, 2,5-dichlorophenyl, furyl, thienyl and the like.

[00911] Specific Examples include those shown in Table 10:

Table 10

IA

IIB

5-Methyl-1-(2'-pyridyl)-2-(1H) pyridine,	6-Methyl-1-phenyl-3-(1H) pyridone,
6-Methyl-1-phenyl-2-(1H) pyridone,	5-Methyl-1-p-tolyl-3-(1H) pyridone,
5-Methyl-3-phenyl-1-(2'-thienyl)-2-(1H) pyridone,	5-Methyl-1-(2'-naphthyl)-3-(1H) pyridone,
5-Methyl-1-(2'-naphthyl)-2-(1H) pyridone,	5-Methyl-1-phenyl-3-(1H) pyridone,
5-Methyl-1-p-tolyl-2-(1H) pyridone,	5-Methyl-1-(5'-quinolyl)-3-(1H) pyridone,
5-Methyl-1-(1'-naphthyl)-2-(1H) pyridone,	5-Ethyl-1-phenyl-3-(1H) pyridone,
5-Ethyl-1-phenyl-2-(1H) pyridone,	5-Methyl-1-(4'-methoxyphenyl)-3-(1H) pyridone,
5-Methyl-1-(5'-quinolyl)-2-(1H) pyridone,	4-Methyl-1-phenyl-3-(1H) pyridone,
5-Methyl-1-(4'-quinolyl)-2-(1H) pyridone,	5-Methyl-1-(3'-pyridyl)-3-(1H) pyridone,
5-Methyl-1-(4'-pyridyl)-2-(1H) pyridone,	5-Methyl-1-(2'-Thienyl)-3-(1H) pyridone,
3-Methyl-1-phenyl-2-(1H) pyridone,	5-Methyl-1-(2'-pyridyl)-3-(1H) pyridone,
5-Methyl-1-(4'-methoxyphenyl)-2-(1H) pyridone,	5-Methyl-1-(2'-quinolyl)-3-(1H) pyridone,
1-Phenyl-2-(1H) pyridone,	1-Phenyl-3-(1H) pyridine,
1,3-Diphenyl-2-(1H) pyridone,	1-(2'-Furyl)-5-methyl-3-(1H) pyridone,
1,3-Diphenyl-5-methyl-2-(1H) pyridone,	1-(4'-Chlorophenyl)-5-methyl-3-(1H) pyridine.
5-Methyl-1-(3'-trifluoromethylphenyl)-2-(1H)-pyridone,	
3-Ethyl-1-phenyl-2-(1H) pyridone,	
5-Methyl-1-(3'-pyridyl)-2-(1H) pyridone,	
5-Methyl-1-(3-nitrophenyl)-2-(1H) pyridone,	
3-(4'-Chlorophenyl)-5-Methyl-1-phenyl-2-(1H) pyridone,	
5-Methyl-1-(2'-Thienyl)-2-(1H) pyridone,	
5-Methyl-1-(2'-thiazolyl)-2-(1H) pyridone,	
3,6-Dimethyl-1-phenyl-2-(1H) pyridone,	

1-(4-Chlorophenyl)-5-Methyl-2-(1H) pyridone,	
1-(2'-Imidazolyl)-5-Methyl-2-(1H) pyridone,	
1-(4'-Nitrophenyl)-2-(1H) pyridone,	
1-(2'-Furyl)-5-Methyl-2-(1H) pyridone,	
1-Phenyl-3-(4'-chlorophenyl)-2-(1H) pyridine.	

[00912] U.S. Pat. Nos. 3,974,281; 3,839,346; 4,042,699; 4,052,509; 5,310,562; 5,518,729; 5,716,632; and 6,090,822 describe methods for the synthesis and formulation of pirfenidone and specific pirfenidone analogs in pharmaceutical compositions suitable for use in the methods of the present invention.

#### **TNF Antagonists**

[00913] Suitable TNF- $\alpha$  antagonists for use herein include agents that decrease the level of TNF- $\alpha$  synthesis, agents that block or inhibit the binding of TNF- $\alpha$  to a TNF- $\alpha$  receptor (TNFR), and agents that block or inhibit TNFR-mediated signal transduction. Unless otherwise expressly stated, every reference to a "TNF- $\alpha$  antagonist" or "TNF antagonist" herein will be understood to mean a TNF- $\alpha$  antagonist other than SAPK inhibitors (including pirfenidone and pirfenidone analogs).

[00914] As used herein, the terms "TNF receptor polypeptide" and "TNFR polypeptide" refer to polypeptides derived from TNFR (from any species) that are capable of binding TNF. Two distinct cell-surface TNFRs have been described: Type II TNFR (or p75 TNFR or TNFR<sub>II</sub>) and Type I TNFR (or p55 TNFR or TNFR<sub>I</sub>). The mature full-length human p75 TNFR is a glycoprotein having a molecular weight of about 75-80 kilodaltons (kD). The mature full-length human p55 TNFR is a glycoprotein having a molecular weight of about 55-60 kD. Exemplary TNFR polypeptides are derived from TNFR Type I and/or TNFR type II. Soluble TNFR includes p75 TNFR polypeptide; fusions of p75 TNFR with heterologous fusion partners, e.g., the Fc portion of an immunoglobulin.

[00915] TNFR polypeptide may be an intact TNFR or a suitable fragment of TNFR. U.S. Pat. No. 5,605,690 provides examples of TNFR polypeptides, including soluble TNFR polypeptides, appropriate for use in the present invention. In many embodiments, the TNFR polypeptide comprises an extracellular domain of TNFR. In some embodiments, the TNFR polypeptide is a fusion polypeptide comprising an extracellular domain of TNFR linked to a constant domain of an immunoglobulin molecule. In other embodiments, the TNFR polypeptide is a fusion polypeptide comprising an extracellular domain of the p75 TNFR

linked to a constant domain of an IgG1 molecule. In some embodiments, when administration to humans is contemplated, an Ig used for fusion proteins is human, e.g., human IgG1.

[00916] Monovalent and multivalent forms of TNFR polypeptides may be used in the present invention. Multivalent forms of TNFR polypeptides possess more than one TNF binding site. In some embodiments, the TNFR is a bivalent, or dimeric, form of TNFR. For example, as described in U.S. Pat. No. 5,605,690 and in Mohler et al., 1993, *J. Immunol.*, 151:1548-1561, a chimeric antibody polypeptide with TNFR extracellular domains substituted for the variable domains of either or both of the immunoglobulin heavy or light chains would provide a TNFR polypeptide for the present invention. Generally, when such a chimeric TNFR:antibody polypeptide is produced by cells, it forms a bivalent molecule through disulfide linkages between the immunoglobulin domains. Such a chimeric TNFR:antibody polypeptide is referred to as TNFR:Fc.

[00917] In one embodiment, a subject method involves administration of an effective amount of the soluble TNFR ENBREL® etanercept. ENBREL® is a dimeric fusion protein consisting of the extracellular ligand-binding portion of the human 75 kilodalton (p75) TNFR linked to the Fc portion of human IgG1. The Fc component of ENBREL® contains the CH2 domain, the CH3 domain and hinge region, but not the CH1 domain of IgG1. ENBREL® is produced in a Chinese hamster ovary (CHO) mammalian cell expression system. It consists of 934 amino acids and has an apparent molecular weight of approximately 150 kilodaltons. Smith et al. (1990) *Science* 248:1019-1023; Mohler et al. (1993) *J. Immunol.* 151:1548-1561; U.S. Pat. No. 5,395,760; and U.S. Pat. No. 5,605,690.

[00918] Also suitable for use are monoclonal antibodies that bind TNF- $\alpha$ . Monoclonal antibodies include "humanized" mouse monoclonal antibodies; chimeric antibodies; monoclonal antibodies that are at least about 80%, at least about 90%, at least about 95%, or 100% human in amino acid sequence; and the like. See, e.g., WO 90/10077; WO 90/04036; and WO 92/02190. Suitable monoclonal antibodies include antibody fragments, such as Fv, F(ab')<sub>2</sub> and Fab; synthetic antibodies; artificial antibodies; phage display antibodies; and the like.

[00919] Examples of suitable monoclonal antibodies include infliximab (REMICADE®, Centocor); and adalimumab (HUMIRA™, Abbott). REMICADE® is a chimeric monoclonal anti-TNF- $\alpha$  antibody that includes about 25% mouse amino acid sequence and about 75% human amino acid sequence. REMICADE® comprises a variable region of a mouse monoclonal anti-TNF- $\alpha$  antibody fused to the constant region of a human IgG1. Elliott et al. (1993) *Arthritis Rheum.* 36:1681-1690; Elliott et al. (1994) *Lancet* 344:1105-1110; Baert et al.

(1999) *Gastroenterology* 116:22-28. HUMIRA™ is a human, full-length IgG1 monoclonal antibody that was identified using phage display technology. Piascik (2003) *J. Am. Pharm. Assoc.* 43:327-328.

[00920] Methods to assess TNF antagonist activity are known in the art and exemplified herein. For example, TNF antagonist activity may be assessed with a cell-based competitive binding assay. In such an assay, radiolabeled TNF is mixed with serially diluted TNF antagonist and cells expressing cell membrane bound TNFR. Portions of the suspension are centrifuged to separate free and bound TNF and the amount of radioactivity in the free and bound fractions determined. TNF antagonist activity is assessed by inhibition of TNF binding to the cells in the presence of the TNF antagonist.

[00921] As another example, TNF antagonists may be analyzed for the ability to neutralize TNF activity in vitro in a bioassay using cells susceptible to the cytotoxic activity of TNF as target cells. In such an assay, target cells, cultured with TNF, are treated with varying amounts of TNF antagonist and subsequently are examined for cytolysis. TNF antagonist activity is assessed by a decrease in TNF-induced target cell cytolysis in the presence of the TNF antagonist.

#### **TGF- $\beta$ Antagonists**

[00922] TGF- $\beta$  antagonists suitable for use in a subject treatment method include agents that decrease the level of TGF- $\beta$  synthesis, agents that block or inhibit the binding of TGF- $\beta$  to a TGF- $\beta$  receptor, and agents that block or inhibit TGF- $\beta$  receptor-mediated signal transduction. As used herein, the term "TGF- $\beta$  antagonist" refers to any agent that decreases the level of TGF- $\beta$  synthesis, any agent that blocks or inhibits the binding of TGF- $\beta$  to a TGF- $\beta$  receptor, and any agent that blocks or inhibits TGF- $\beta$  receptor-mediated signal transduction. Unless otherwise expressly stated, every reference to a "TGF- $\beta$  antagonist" herein will be understood to mean a TGF- $\beta$  antagonist other than SAPK inhibitors (including pirfenidone and pirfenidone analogs). As used herein, the term "TGF- $\beta$ " includes any TGF- $\beta$  subtype, including TGF- $\beta$ 1, TGF- $\beta$ 2, and TGF- $\beta$ 3. Suitable TGF- $\beta$  antagonists include, but are not limited to, antibodies specific for TGF- $\beta$  (including antibodies specific for a particular TGF- $\beta$  subtype; and antibodies cross-reactive with two or more TGF- $\beta$  subtypes); antibodies to TGF- $\beta$  receptor; soluble TGF- $\beta$  receptor; decorin; and agents that inhibit TGF- $\beta$  signaling.

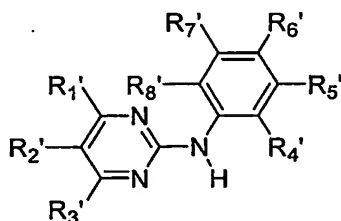
[00923] Suitable TGF- $\beta$  antagonists include antibodies specific for TGF- $\beta$ . Antibodies specific for TGF- $\beta$  are known in the art. See, e.g., U.S. Patent Nos. 5,783,185, 5,772,998, 5,674,843, 5,571,714, 5,462,925, and 5,426,098; WO 97/13844; and U.S. Patent Publication Nos 20030064069 and 20030091566. Non-limiting examples of suitable anti-TGF- $\beta$  antibodies

include CAT-152 (lerdelimumab; Trabio™; Cambridge Antibody Technology), a human anti-TGF-β2 monoclonal antibody; CAT-192 (metelimumab; Cambridge Antibody Technology), a human anti-TGF-β1 monoclonal antibody; and GC-1008 (Genzyme Corp.), a pan-specific human monoclonal antibody to TGF-β1, TGF-β2, and TGF-β3.

[00924] Suitable TGF-β antagonists include soluble TGF-β receptors. Soluble TGF-β receptors typically lack most or all of the transmembrane portion of a naturally-occurring TGF-β receptor, such that the protein is not membrane bound, yet retains TGF-β binding. Soluble TGF-β receptors include soluble fusion proteins comprising a portion of a TGF-β receptor fused in-frame to a heterologous (non-TGF-β receptor) protein (a “fusion partner”). Non-limiting examples of fusion partners are immunoglobulin Fc, poly-histidine, and the like. Soluble TGF-β receptors have been described in the art. See, e.g., Wang et al. (1999) *Thorax* 54:805-812; George et al. (1999) *Proc. Natl. Acad. Sci. USA* 96:12719-12724; Muraoka et al. (2002) *J. Clin. Invest.* 109:1551-1559; and Yata et al. (2002) *Hepatology* 35:1022-1030.

[00925] TGF-β antagonists include Gleevec™. Gleevec™ (also known as STI-571, or CGP57148B) has the chemical name 4-[(4-methyl-1-piperazinyl)methyl]-N-[4-methyl-3-[[4-(3-pyridinyl)-2-pyrimidinyl]amino-phenyl]benzamide methanesulfonate is commonly known as imatinib mesylate and sold under the trademark Gleevec™. Gleevec™ is a 2-phenylaminopyrimidine that targets the ATP-binding site of the kinase domain of Bcr-Abl tyrosine kinase (see, e.g. Druker et al. (1996) *Nature Med.* 2, 561; and Buchdunger et al. (1993) *Proc. Natl. Acad. Sci. USA* 92:2558-2562).

[00926] In certain embodiments, the agents are pyrimidine derivatives as described in U.S. Patent No. 5,521,184, the disclosure of which is herein incorporated by reference. In these embodiments, of interest are N-phenyl-2-pyrimidine-amine derivatives of formula (I):



[00927] wherein

[00928] R<sub>9</sub>' is hydrogen or lower alkyl,

[00929] X is oxo, thio, imino, N-lower alkyl-imino, hydroximino or O-lower alkyl-hydroximino,

- [00930]  $\dot{Y}$  is oxygen or the group  $\text{NH}$ ,
- [00931]  $k$  is 0 or 1 and
- [00932]  $\text{R}_{10}$  is an aliphatic radical having at least 5 carbon atoms, or an aromatic, aromatic-aliphatic, cycloaliphatic, cycloaliphatic-aliphatic, heterocyclic or heterocyclic-aliphatic radical,
- [00933] and the remaining radicals  $\text{R}_4$ ,  $\text{R}_5$ ,  $\text{R}_6$ ,  $\text{R}_7$  and  $\text{R}_8$  are each independently of the others hydrogen, lower alkyl that is unsubstituted or substituted by free or alkylated amino, piperazinyl, piperidinyl, pyrrolidinyl or by morpholinyl, or lower alkanoyl, trifluoromethyl, free, etherified or esterified hydroxy, free, alkylated or acylated amino or free or esterified carboxy,
- [00934] and salts of such compounds having at least one salt-forming group.
- [00935] In these embodiments:
- [00936] 1-Methyl-1H-pyrrolyl is preferably 1-methyl-1H-pyrrol-2-yl or 1-methyl-1H-pyrrol-3-yl.
- [00937] Amino- or amino-lower alkyl-substituted phenyl  $\text{R}_1$  wherein the amino group in each case is free, alkylated or acylated, is phenyl substituted in any desired position (ortho, meta or para) wherein an alkylated amino group is preferably mono- or di-lower alkylamino, for example dimethylamino, and the lower alkyl moiety of amino-lower alkyl is preferably linear  $\text{C}_1$ - $\text{C}_3$  alkyl, such as especially methyl or ethyl.
- [00938] 1H-Indolyl bonded at a carbon atom of the five-membered ring is 1H-indol-2-yl or 1H-indol-3-yl.
- [00939] Unsubstituted or lower alkyl-substituted pyridyl bonded at a ring carbon atom is lower alkyl-substituted or preferably unsubstituted 2-, or preferably 3- or 4-pyridyl, for example 3-pyridyl, 2-methyl-3-pyridyl, 4-methyl-3-pyridyl or 4-pyridyl. Pyridyl substituted at the nitrogen atom by oxygen is a radical derived from pyridine N-oxide, i.e., N-oxido-pyridyl, e.g. N-oxido-4-pyridyl.
- [00940] Fluoro-substituted lower alkoxy is lower alkoxy carrying at least one, but preferably several, fluoro substituents, especially trifluoromethoxy or preferably 1,1,2,2-tetrafluoroethoxy.
- [00941] When X is oxo, thio, imino, N-lower alkyl-imino, hydroximino or O-lower alkyl-hydroximino, the group  $\text{C}=\text{X}$  is, in the above order, a radical  $\text{C}=\text{O}$ ,  $\text{C}=\text{S}$ ,  $\text{C}=\text{N}-\text{H}$ ,  $\text{C}=\text{N}$ -lower alkyl,  $\text{C}=\text{N}-\text{OH}$  or  $\text{CN}-\text{O}$ -lower alkyl, respectively. X is preferably oxo.
- [00942]  $k$  is preferably 0, i.e., the group Y is not present.
- [00943] Y, if present, is preferably the group  $\text{NH}$ .



[00944] The term "lower" within the scope of this text denotes radicals having up to and including 7, preferably up to and including 4 carbon atoms.

[00945] Lower alkyl  $R_1$ ,  $R_2$ ,  $R_3$  and  $R_9$  is preferably methyl or ethyl.

[00946] An aliphatic radical  $R_{10}$  having at least 5 carbon atoms preferably has not more than 22 carbon atoms, generally not more than 10 carbon atoms, and is such a substituted or preferably unsubstituted aliphatic hydrocarbon radical, that is to say such a substituted or preferably unsubstituted alkynyl, alkenyl or preferably alkyl radical, such as  $C_5$  - $C_7$  alkyl, for example n-pentyl. An aromatic radical  $R_{10}$  has up to 20 carbon atoms and is unsubstituted or substituted, for example in each case unsubstituted or substituted naphthyl, such as especially 2-naphthyl, or preferably phenyl, the substituents preferably being selected from cyano, unsubstituted or hydroxy-, amino- or 4-methyl-piperazinyl-substituted lower alkyl, such as especially methyl, trifluoromethyl, free, etherified or esterified hydroxy, free, alkylated or acylated amino and free or esterified carboxy. In an aromatic-aliphatic radical  $R_{10}$  the aromatic moiety is as defined above and the aliphatic moiety is preferably lower alkyl, such as especially  $C_1$  - $C_2$  alkyl, which is substituted or preferably unsubstituted, for example benzyl. A cycloaliphatic radical  $R_{10}$  has especially up to 30, more especially up to 20, and most especially up to 10 carbon atoms, is mono- or poly-cyclic and is substituted or preferably unsubstituted, for example such a cycloalkyl radical, especially such a 5- or 6-membered cycloalkyl radical, such as preferably cyclohexyl. In a cycloaliphatic-aliphatic radical  $R_{10}$  the cycloaliphatic moiety is as defined above and the aliphatic moiety is preferably lower alkyl, such as especially  $C_1$  - $C_2$  alkyl, which is substituted or preferably unsubstituted. A heterocyclic radical  $R_{10}$  contains especially up to 20 carbon atoms and is preferably a saturated or unsaturated monocyclic radical having 5 or 6 ring members and 1-3 hetero atoms which are preferably selected from nitrogen, oxygen and sulfur, especially, for example, thienyl or 2-, 3- or 4-pyridyl, or a bi- or tri-cyclic radical wherein, for example, one or two benzene radicals are annellated (fused) to the mentioned monocyclic radical. In a heterocyclic-aliphatic radical  $R_{10}$  the heterocyclic moiety is as defined above and the aliphatic moiety is preferably lower alkyl, such as especially  $C_1$  - $C_2$  alkyl, which is substituted or preferably unsubstituted.

[00947] Etherified hydroxy is preferably lower alkoxy. Esterified hydroxy is preferably hydroxy esterified by an organic carboxylic acid, such as a lower alkanolic acid, or a mineral acid, such as a hydrohalic acid, for example lower alkanoyloxy or especially halogen, such as iodine, bromine or especially fluorine or chlorine.

- [00948] Alkylated amino is, for example, lower alkylamino, such as methylamino, or di-lower alkylamino, such as dimethylamino. Acylated amino is, for example, lower alkanoylamino or benzoylamino.
- [00949] Esterified carboxy is, for example, lower alkoxy-carbonyl, such as methoxycarbonyl.
- [00950] A substituted phenyl radical may carry up to 5 substituents, such as fluorine, but especially in the case of relatively large substituents is generally substituted by only from 1 to 3 substituents. Examples of substituted phenyl that may be given special mention are 4-chlorophenyl, pentafluorophenyl, 2-carboxyphenyl, 2-methoxyphenyl, 4-fluorophenyl, 4-cyanophenyl and 4-methylphenyl.
- [00951] Salt-forming groups in a compound of formula (I) are groups or radicals having basic or acidic properties. Compounds having at least one basic group or at least one basic radical, for example a free amino group, a pyrazinyl radical or a pyridyl radical, may form acid addition salts, for example with inorganic acids, such as hydrochloric acid, sulfuric acid or a phosphoric acid, or with suitable organic carboxylic or sulfonic acids, for example aliphatic mono- or di-carboxylic acids, such as trifluoroacetic acid, acetic acid, propionic acid, glycolic acid, succinic acid, maleic acid, fumaric acid, hydroxymaleic acid, malic acid, tartaric acid, citric acid or oxalic acid, or amino acids such as arginine or lysine, aromatic carboxylic acids, such as benzoic acid, 2-phenoxybenzoic acid, 2-acetoxybenzoic acid, salicylic acid, 4-aminosalicylic acid, aromatic-aliphatic carboxylic acids, such as mandelic acid or cinnamic acid, heteroaromatic carboxylic acids, such as nicotinic acid or isonicotinic acid, aliphatic sulfonic acids, such as methane-, ethane- or 2-hydroxyethane-sulfonic acid, or aromatic sulfonic acids, for example benzene-, p-toluene- or naphthalene-2-sulfonic acid. When several basic groups are present mono- or poly-acid addition salts may be formed.
- [00952] Compounds of formula (I) having acidic groups, for example a free carboxy group in the radical  $R_{10}$ , may form metal or ammonium salts, such as alkali metal or alkaline earth metal salts, for example sodium, potassium, magnesium or calcium salts, or ammonium salts with ammonia or suitable organic amines, such as tertiary monoamines, for example triethylamine or tri-(2-hydroxyethyl)-amine, or heterocyclic bases, for example N-ethylpiperidine or N,N'-dimethyl-piperazine.
- [00953] Compounds of formula (I) having both acidic and basic groups can form internal salts.
- [00954] Of particular interest in these embodiments is a pyrimidine derivative in which  $R_{1'}$  is 3-pyridyl,  $R_{2'}$ ,  $R_{3'}$ ,  $R_{5'}$ ,  $R_{6'}$ , and  $R_{8'}$  are each hydrogen,  $R_{4'}$  is methyl, and  $R_{7'}$  is a group of formula (II) in which  $R_9$  is hydrogen, X is oxo,  $k$  is 0, and  $R_{10}$  is 4-[(4-methyl-1-piperazinyl)methyl]phenyl. The mesylate salt of this compound having the chemical name 4-

[(4-methyl-1-piperazinyl)methyl]-*N*-[4-methyl-3-[[4-(3-pyridinyl)-2-pyrimidinyl]amino-phenyl]benzamide methanesulfonate is now commonly known as imatinib mesylate and sold under the trademark Gleevec™.

### Endothelin Receptor Antagonists

[00955] Endothelin antagonists suitable for use in the present invention include agents that decrease the level of endothelin synthesis, agents that block or inhibit the binding of endothelin to an endothelin receptor, and agents that block or inhibit endothelin receptor-mediated signal transduction. As used herein, the term “endothelin antagonist” refers to any agent that decreases the level of endothelin synthesis, any agent that blocks or inhibits the binding of endothelin to an endothelin receptor, and any agent that blocks or inhibits endothelin receptor-mediated signal transduction.

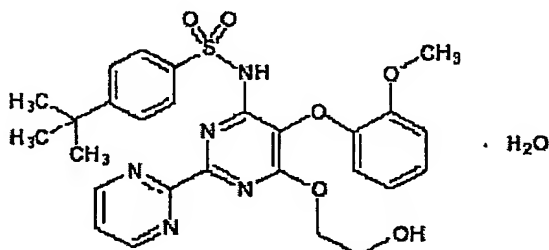
[00956] In some embodiments, an endothelin receptor antagonist is selective for endothelin A (ETA) receptors. In some embodiments, an endothelin receptor antagonist is selective for endothelin B (ETB) receptors. In other embodiments, an endothelin receptor antagonist is an antagonist of both ETA and ETB receptors.

[00957] Specific examples of endothelin antagonists useful in the present invention include, but are not limited to, atrasentan (ABT-627; Abbott Laboratories), Veletri™ (tezosentan; Actelion Pharmaceuticals, Ltd.), sitaxsentan (ICOS-Texas Biotechnology), enrasentan (GlaxoSmithKline), darusentan (LU135252; Myogen) BMS-207940 (Bristol-Myers Squibb), BMS-193884 (Bristol-Myers Squibb), BMS-182874 (Bristol-Myers Squibb), J-104132 (Banyu Pharmaceutical), VML 588/Ro 61-1790 (Vanguard Medica), T-0115 (Tanabe Seiyaku), TAK-044 (Takeda), BQ-788 (Banyu Pharmaceutical), BQ123, YM-598 (Yamanouchi Pharma), PD 145065 (Parke-Davis), A-127722 (Abbott Laboratories), A-192621 (Abbott Laboratories), A-182086 (Abbott Laboratories), TBC3711 (ICOS-Texas Biotechnology), BSF208075 (Myogen), S-0139 (Shionogi), TBC2576 (Texas Biotechnology), TBC3214 (Texas Biotechnology), PD156707 (Parke-Davis), PD180988 (Parke-Davis), ABT-546 (Abbott Laboratories), ABT-627 (Abbott Laboratories), SB247083 (GlaxoSmithKline), SB 209670 (GlaxoSmithKline); and an endothelin receptor antagonists discussed in the art, e.g., Davenport and Battistini (2002) *Clinical Science* 103:15-35, Wu-Wong et al. (2002) *Clinical Science* 103:1075-1115, and Luescher and Barton (2000) *Circulation* 102:2434-2440.

[00958] A suitable endothelin receptor antagonist is TRACLEER™ (bosentan; manufactured by Actelion Pharmaceuticals, Ltd.). TRACLEER™ is an orally active dual endothelin receptor antagonist, and blocks the binding of endothelin to both of its receptors endothelin receptor A and endothelin receptor B.

[00959] TRACLEER™ belongs to a class of highly substituted pyrimidine derivatives, with no chiral centers. It is designated chemically as 4-tert-butyl-N-[6-(2-hydroxy-ethoxy)-5-(2-methoxy-phenoxy)-[2,2']-bipyrimidin-4-yl]-benzenesulfonamide monohydrate and has the following structural formula:

[00960]



[00961] TRACLEER™ treatment is in some embodiments administered at a dose of 62.5 mg bid orally for 4 weeks, followed by a maintenance dose of 125 mg bid orally.

#### N-Acetylcysteine (NAC)

[00962] N-acetylcysteine (NAC) is a stable form of the sulfur amino acid L-cysteine. NAC is an anti-oxidant that scavenges H<sub>2</sub>O<sub>2</sub> and other radicals. It is a precursor of glutathione (a major antioxidant), providing cysteine substrate for glutathione synthesis. NAC is commercially available as an over-the-counter nutritional supplement or nutraceutical product. Suitable NAC products for use herein include the NAC nutritional supplement products made by Source Naturals (1000 mg tablets), Biochem (750 mg tablets), Twinlab (600 mg tablets), Nutricology/Allergy Research Group (500 mg tablets), and the like. Such products can be purchased at minimal cost from health food stores and nutritional supplement retailers, such as General Nutrition Corporation (GNC).

#### Thymosin-α

[00963] Thymosin-α (Zadaxin™; available from SciClone Pharmaceuticals, Inc., San Mateo, CA) is a synthetic form of thymosin alpha 1, a hormone found naturally in the circulation and produced by the thymus gland. Thymosin-α increases activity of T cells and NK cells. Zadaxin™ formulated for subcutaneous injection is a purified sterile lyophilized preparation of chemically synthesized thymosin alpha 1 identical to human thymosin alpha 1. Thymosin alpha 1 is an acetylated polypeptide with the following sequence: Ac - Ser - Asp - Ala - Ala - Val - Asp - Thr - Ser - Ser - Glu - Ile - Thr - Thr - Lys - Asp - Leu - Lys - Glu - Lys - Lys - Glu - Val - Val - Glu - Glu - Ala - Glu - Asn - OH (SEQ ID NO: 103), and having a molecular

weight of 3,108 daltons. The lyophilized preparation contains 1.6 mg synthetic thymosin- $\alpha$ , 50 mg mannitol, and sodium phosphate buffer to adjust the pH to 6.8.

### Ribavirin

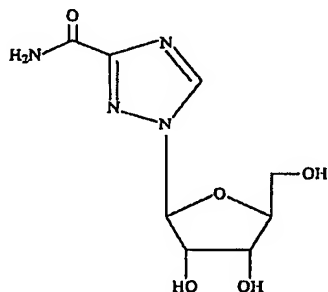
[00964] Ribavirin, 1- $\beta$ -D-ribofuranosyl-1H-1,2,4-triazole-3-carboxamide, available from ICN Pharmaceuticals, Inc., Costa Mesa, Calif., is described in the Merck Index, compound No. 8199, Eleventh Edition. Its manufacture and formulation is described in U.S. Pat. No. 4,211,771. The invention also contemplates use of derivatives of ribavirin (see, *e.g.*, U.S. Pat. No. 6,277,830). The ribavirin may be administered orally in capsule or tablet form, or in the same or different administration form and in the same or different route as the IFN- $\alpha$  (either PEGylated or non-PEGylated form). Of course, other types of administration of both medicaments, as they become available are contemplated, such as by nasal spray, transdermally, by suppository, by sustained release dosage form, etc. Any form of administration will work so long as the proper dosages are delivered without destroying the active ingredient.

[00965] Ribavirin is generally administered in an amount ranging from about 400 mg to about 1200 mg, from about 600 mg to about 1000 mg, or from about 700 to about 900 mg per day. In some embodiments, ribavirin is administered throughout the entire course of PEGylated IFN- $\alpha$  or non-PEGylated IFN- $\alpha$  therapy. In other embodiments, ribavirin is administered only during the first period of time. In still other embodiments, ribavirin is administered only during the second period of time.

### Levovirin

[00966] Levovirin is the L-enantiomer of ribavirin, and exhibits the property of enhancing a Th1 immune response over a Th2 immune response. Levovirin is manufactured by ICN Pharmaceuticals.

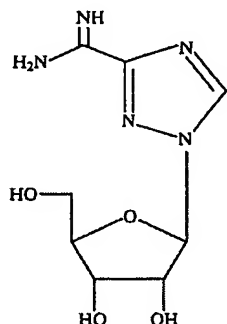
[00967] Levovirin has the following structure:



## Viramidine

[00968] Viramidine is a 3-carboxamidine derivative of ribavirin, and acts as a prodrug of ribavirin. It is efficiently converted to ribavirin by adenosine deaminases.

[00969] Viramidine has the following structure:



## Nucleoside analogs

[00970] Nucleoside analogs that are suitable for use in a subject therapy include, but are not limited to, ribavirin, levovirin, viramidine, isatoribine, an L-ribofuranosyl nucleoside as disclosed in U.S. Patent No. 5,559,101 and encompassed by Formula I of U.S. Patent No. 5,559,101 (e.g., 1-β-L-ribofuranosyluracil, 1-β-L-ribofuranosyl-5-fluorouracil, 1-β-L-ribofuranosylcytosine, 9-β-L-ribofuranosyladenine, 9-β-L-ribofuranosylhypoxanthine, 9-β-L-ribofuranosylguanine, 9-β-L-ribofuranosyl-6-thioguanine, 2-amino-α-L-ribofuran[1',2':4,5]oxazoline, O<sup>2</sup>,O<sup>2</sup>-anhydro-1-α-L-ribofuranosyluracil, 1-α-L-ribofuranosyluracil, 1-(2,3,5-tri-O-benzoyl-α-ribofuranosyl)-4-thiouracil, 1-α-L-ribofuranosylcytosine, 1-α-L-ribofuranosyl-4-thiouracil, 1-α-L-ribofuranosyl-5-fluorouracil, 2-amino-β-L-arabinofurano[1',2':4,5]oxazoline, O<sup>2</sup>,O<sup>2</sup>-anhydro-β-L-arabinofuranosyluracil, 2'-deoxy-β-L-uridine, 3'5'-Di-O-benzoyl-2'-deoxy-4-thio β-L-uridine, 2'-deoxy-β-L-cytidine, 2'-deoxy-β-L-4-thiouridine, 2'-deoxy-β-L-thymidine, 2'-deoxy-β-L-5-fluorouridine, 2',3'-dideoxy-β-L-uridine, 2'-deoxy-β-L-5-fluorouridine, and 2'-deoxy-β-L-inosine); a compound as disclosed in U.S. Patent No. 6,423,695 and encompassed by Formula I of U.S. Patent No. 6,423,695; a compound as disclosed in U.S. Patent Publication No. 2002/0058635, and encompassed by Formula 1 of U.S. Patent Publication No. 2002/0058635; a nucleoside analog as disclosed in WO 01/90121 A2 (Idenix); a nucleoside analog as disclosed in WO 02/069903 A2 (Biocryst Pharmaceuticals Inc.); a nucleoside analog as disclosed in WO 02/057287 A2 or WO 02/057425 A2 (both Merck/Isis); and the like.

**HCV NS3 inhibitors**

[00971] Suitable HCV non-structural protein-3 (NS3) inhibitors include, but are not limited to, a tri-peptide as disclosed in U.S. Patent Nos. 6,642,204, 6,534,523, 6,420,380, 6,410,531, 6,329,417, 6,329,379, and 6,323,180 (Boehringer-Ingelheim); a compound as disclosed in U.S. Patent No. 6,143,715 (Boehringer-Ingelheim); a macrocyclic compound as disclosed in U.S. Patent no. 6,608,027 (Boehringer-Ingelheim); an NS3 inhibitor as disclosed in U.S. Patent Nos. 6,617,309, 6,608,067, and 6,265,380 (Vertex Pharmaceuticals); an azapeptide compound as disclosed in U.S. Patent No. 6,624,290 (Schering); a compound as disclosed in U.S. Patent No. 5,990,276 (Schering); a compound as disclosed in Pause et al. (2003) *J. Biol. Chem.* 278:20374-20380; NS3 inhibitor BILN 2061 (Boehringer-Ingelheim; Lamarre et al. (2002) *Hepatology* 36:301A; and Lamarre et al. (Oct. 26, 2003) *Nature* doi:10.1038/nature02099); NS3 inhibitor VX-950 (Vertex Pharmaceuticals; Kwong et al. (Oct. 24-28, 2003) 54<sup>th</sup> Ann. Meeting AASLD); NS3 inhibitor SCH6 (Abib et al. (October 24-28, 2003) Abstract 137. Program and Abstracts of the 54<sup>th</sup> Annual Meeting of the American Association for the Study of Liver Diseases (AASLD). October 24-28, 2003. Boston, MA.); any of the NS3 protease inhibitors disclosed in WO 99/07733, WO 99/07734, WO 00/09558, WO 00/09543, WO 00/59929 or WO 02/060926 (e.g., compounds 2, 3, 5, 6, 8, 10, 11, 18, 19, 29, 30, 31, 32, 33, 37, 38, 55, 59, 71, 91, 103, 104, 105, 112, 113, 114, 115, 116, 120, 122, 123, 124, 125, 126 and 127 disclosed in the table of pages 224-226 in WO 02/060926); an NS3 protease inhibitor as disclosed in any one of U.S. Patent Publication Nos. 2003019067, 20030187018, and 20030186895; and the like.

[00972] Of particular interest in many embodiments are NS3 inhibitors that are specific NS3 inhibitors, e.g., NS3 inhibitors that inhibit NS3 serine protease activity and that do not show significant inhibitory activity against other serine proteases such as human leukocyte elastase, porcine pancreatic elastase, or bovine pancreatic chymotrypsin, or cysteine proteases such as human liver cathepsin B.

[00973] Of particular interest in some embodiments as NS3 inhibitors that inhibit HCV non-structural protein-4 (NS4) helicase activity and that do not show significant inhibitory activity against other serine proteases such as human leukocyte elastase, porcine pancreatic elastase, or bovine pancreatic chymotrypsin, or cysteine proteases such as human liver cathepsin B.

**NS5B inhibitors**

[00974] Suitable HCV non-structural protein-5 (NS5; RNA-dependent RNA polymerase) inhibitors include, but are not limited to, a compound as disclosed in U.S. Patent No. 6,479,508 (Boehringer-Ingelheim); a compound as disclosed in any of International Patent Application

Nos. PCT/CA02/01127, PCT/CA02/01128, and PCT/CA02/01129, all filed on July 18, 2002 by Boehringer Ingelheim; a compound as disclosed in U.S. Patent No. 6,440,985 (ViroPharma); a compound as disclosed in WO 01/47883, e.g., JTK-003 (Japan Tobacco); a dinucleotide analog as disclosed in Zhong et al. (2003) *Antimicrob. Agents Chemother.* 47:2674-2681; a benzothiadiazine compound as disclosed in Dhanak et al. (2002) *J. Biol. Chem.* 277(41):38322-7; an NS5B inhibitor as disclosed in WO 02/100846 A1 or WO 02/100851 A2 (both Shire); an NS5B inhibitor as disclosed in WO 01/85172 A1 or WO 02/098424 A1 (both Glaxo SmithKline); an NS5B inhibitor as disclosed in WO 00/06529 or WO 02/06246 A1 (both Merck); an NS5B inhibitor as disclosed in WO 03/000254 (Japan Tobacco); an NS5B inhibitor as disclosed in EP 1 256,628 A2 (Agouron); JTK-002 (Japan Tobacco); JTK-109 (Japan Tobacco); and the like.

[00975] Of particular interest in many embodiments are NS5 inhibitors that are specific NS5 inhibitors, e.g., NS5 inhibitors that inhibit NS5 RNA-dependent RNA polymerase and that lack significant inhibitory effects toward other RNA dependent RNA polymerases and toward DNA dependent RNA polymerases.

#### **Alpha-Glucosidase Inhibitors**

[00976] Alpha-glucosidase inhibitors are a class of oral medications for type 2 diabetes that decrease the absorption of carbohydrates from the intestine, resulting in a slower rise in blood glucose throughout the day, especially following meals, in type 2 diabetic patients. Alpha-glucosidase inhibitors suitable for use in a subject combination therapy include, but are not limited to, n-(n-nonyl)-deoxygalactonojirimycin (n,n-DGJ); N-nonyl-deoxynojirimycin (N-nonyl-DNJ); N-butyl-deoxynojirimycin (NB-DNJ); 1-deoxynojirimycin (DNM); perbutylated-N-butyl-1-deoxynojiromycin (p-N-butyl-DNJ); and 6-O-butanoyl castanospermine; and the like.

#### **Additional antiviral therapeutic agents**

[00977] Additional antiviral therapeutic agents that can be administered in a subject combination therapy include, but are not limited to, alpha-glucosidase inhibitors; inhibitors of inosine monophosphate dehydrogenase (IMPDH); ribozymes that are complementary to viral nucleotide sequences; antisense RNA inhibitors; and the like.

#### *Alpha-glucosidase inhibitors*

[00978] Alpha-glucosidase inhibitors are a class of oral medications for type 2 diabetes that decrease the absorption of carbohydrates from the intestine, resulting in a slower rise in blood glucose throughout the day, especially following meals, in type 2 diabetic patients. Alpha-glucosidase inhibitors suitable for use in a subject combination therapy include, but are not



limited to, n-(n-nonyl)-deoxygalactonojirimycin (n,n-DGJ); N-nonyl-deoxynojirimycin (N-nonyl-DNJ); N-butyl-deoxynojirimycin (NB-DNJ); 1-deoxynojirimycin (DNM); perbutylated-N-butyl-1-deoxynojirimycin (p-N-butyl-DNJ); and 6-O-butanoyl castanospermine; and the like.

#### *IMPDH inhibitors*

[00979] IMPDH inhibitors that are suitable for use in a subject combination therapy include, but are not limited to, VX-497 ((*S*)-*N*-3-[3-(3-methoxy-4-oxazol-5-yl-phenyl)-ureido]-benzyl-carbamic acid tetrahydrofuran-3-yl-ester); Vertex Pharmaceuticals; see, e.g., Markland et al. (2000) *Antimicrob. Agents Chemother.* 44:859-866); ribavirin; levovirin (Ribapharm; see, e.g., Watson (2002) *Curr Opin Investig Drugs* 3(5):680-3); viramidine (Ribapharm); and the like.

#### *Ribozyme and antisense*

[00980] Ribozyme and antisense antiviral agents that are suitable for use in a subject combination therapy include, but are not limited to, ISIS 14803 (ISIS Pharmaceuticals/Elan Corporation; see, e.g., Witherell (2001) *Curr Opin Investig Drugs* 2(11):1523-9); Heptazyme™; and the like.

#### **Side effect management agents**

[00981] In some embodiments, a subject therapy comprises administering a palliative agent (e.g., an agent that reduces patient discomfort caused by a therapeutic agent), or other agent for the avoidance, treatment, or reduction of a side effect of a therapeutic agent. Such agents are also referred to as "side effect management agents."

[00982] Suitable side effect management agents include agents that are effective in pain management; agents that ameliorate gastrointestinal discomfort; analgesics, anti-inflammatories, antipsychotics, antineurotics, anxiolytics, and hematopoietic agents. In addition, the invention contemplates the use of any compound for palliative care of patients suffering from pain or any other side effect in the course of treatment with a subject therapy. Exemplary palliative agents include acetaminophen, ibuprofen, and other NSAIDs, H2 blockers, and antacids.

[00983] Analgesics that can be used to alleviate pain in the methods of the invention include non-narcotic analgesics such as non-steroidal anti-inflammatory drugs (NSAIDs) acetaminophen, salicylate, acetyl-salicylic acid (aspirin, diflunisal), ibuprofen, Motrin, Naprosyn, Nalfon, and Trilisate, indomethacin, glucametacine, acemetacin, sulindac, naproxen, piroxicam, diclofenac, benoxaprofen, ketoprofen, oxaprozin, etodolac, ketorolac tromethamine, ketorolac, nabumetone, and the like, and mixtures of two or more of the foregoing.

[00984] Other suitable analgesics include fentanyl, buprenorphine, codeine sulfate, morphine hydrochloride, codeine, hydromorphone (Dilaudid), levorphanol (Levo-Dromoran), methadone (Dolophine), morphine, oxycodone (in Percodan), and oxymorphone (Numorphan). Also suitable for use are benzodiazepines including, but not limited to, flurazepam (Dalmane), diazepam (Valium), and Versed, and the like.

*Anti-inflammatory agents*

[00985] Suitable anti-inflammatory agents include, but are not limited to, steroidal anti-inflammatory agents, and non-steroidal anti-inflammatory agents.

[00986] Suitable steroidal anti-inflammatory agents include, but are not limited to, hydrocortisone, hydroxyltriamcinolone, alpha-methyl dexamethasone, dexamethasone-phosphate, beclomethasone dipropionate, clobetasol valerate, desonide, desoxymethasone, desoxycorticosterone acetate, dexamethasone, dichlorisone, diflorasone diacetate, diflucortolone valerate, fluadrenolone, flucolorolone acetonide, fludrocortisone, flumethasone pivalate, fluosinolone acetonide, fluocinonide, flucortine butylester, fluocortolone, fluprednidene (fluprednylidene) acetate, flurandrenolone, halcinonide, hydrocortisone acetate, hydrocortisone butyrate, methylprednisolone, triamcinolone acetonide, conisone, cortodoxone, flucetonide, fludrocortisone, difluorosone diacetate, fluradrenolone acetonide, medrysone, amcinafel, amcinafide, betamethasone and the balance of its esters, chloroprednisone, chlorprednisone acetate, clocortelone, clescinolone, dichlorisone, difluprednate, flucoloronide, flunisolide, fluoromethalone, fluperolone, fluprednisolone, hydrocortisone valerate, hydrocortisone cyclopentylpropionate, hydrocortamate, meprednisone, paramethasone, prednisolone, prednisone, beclomethasone dipropionate, triamcinolone, and mixtures of two or more of the foregoing.

[00987] Suitable non-steroidal anti-inflammatory agents, include, but are not limited to, 1) the oxicams, such as piroxicam, isoxicam, tenoxicam, and sudoxicam; 2) the salicylates, such as aspirin, disalcid, benorylate, trilisate, safapryn, solprin, diflunisal, and fendosal; 3) the acetic acid derivatives, such as diclofenac, fenclofenac, indomethacin, sulindac, tolmetin, isoxepac, furofenac, tiopinac, zidometacin, acematacin, fentiazac, zomepiract, clidanac, oxepinac, and felbinac; 4) the fenamates, such as mefenamic, meclofenamic, flufenamic, niflumic, and tolfenamic acids; 5) the propionic acid derivatives, such as ibuprofen, naproxen, benoxaprofen, flurbiprofen, ketoprofen, fenoprofen, fenbufen, indoprofen, pirprofen, carprofen, oxaprozin, pranoprofen, miroprofen, tioxaprofen, suprofen, alminoprofen, and tiaprofenic; and 6) the pyrazoles, such as phenylbutazone, oxyphenbutazone, feprazone, azapropazone, and

trimethazone, mixtures of these non-steroidal anti-inflammatory agents may also be employed, as well as the pharmaceutically-acceptable salts and esters of these agents.

[00988] Suitable anti-inflammatory agents include, but are not limited to, Alclofenac; Alclometasone Dipropionate; Algestone Acetonide; Alpha Amylase; Amcinafal; Amcinafide; Amfenac Sodium; Amiprilose Hydrochloride; Anakinra; Anirolac; Anitrazafen; Apazone; Balsalazide Disodium; Bendazac; Benoxaprofen; Benzydamine Hydrochloride; Bromelains; Broperamole; Budesonide; Carprofen; Cicloprofen; Cintazone; Cliprofen; Clobetasol Propionate; Clobetasone Butyrate; Clopirac; Cloticasone Propionate; Cormethasone Acetate; Cortodoxone; Deflazacort; Desonide; Desoximetasone; -Dexamethasone Dipropionate; Diclofenac Potassium; Diclofenac Sodium; Diflorasone Diacetate; -Diflumidone Sodium; Diflunisal; Difluprednate; Diftalone; Dimethyl Sulfoxide; Drocinnonide; Endrysone; Enlimomab Enolicam Sodium; Epirizole; Etodolac; Etofenamate; Felbinac; Fenamole; Fenbufen; Fenclofenac; Fenclorac; Fendosal; Fempipalzone; Fentiazac; Flazalone; Fluazacort; Flufenamic Acid; Flumizole; Flunisolid Acetate; Flunixin; Flunixin Meglumine; Fluocortin Butyl; Fluorometholone Acetate; Fluquazone; Flurbiprofen; Fluretofen; Fluticasone Propionate; Furaprofen; Furobufen; Halcinnonide; Halobetasol Propionate; Halopredone Acetate; Ibufenac; Ibuprofen; Ibuprofen Aluminum; Ibuprofen Piconol; Ilonidap; Indomethacin; Indomethacin Sodium; Indoprofen; Indoxole; Intrazole; Isoflupredone Acetate; Isoxepac; Isoxicam; Ketoprofen; Lofemizole Hydrochloride; Lornoxicam; Loteprednol Etabonate; Meclofenamate Sodium; Meclofenamic Acid; Meclorisone Dibutyrate; Mefenamic Acid; Mesalamine; Meseclazone; Methylprednisolone Suleptanate; Morniflumate; Nabumetone; Naproxen; Naproxen Sodium; Naproxol; Nimazone; Olsalazine Sodium; Orgotein; Orpanoxin; Oxaprozin; Oxyphenbutazone; Paranyline Hydrochloride; Pentosan Polysulfate Sodium; Phenbutazone Sodium Glycerate; Pirfenidone; Piroxicam; Piroxicam Cinnamate; Piroxicam Olamine; Pirprofen; Prednazate; Prifelone; Prodolic Acid; Proquazone; Proxazole; Proxazole Citrate; Rimexolone; Romazarit; Salcolex; Salnacedin; Salsalate; Sanguinarium Chloride; Seclazone; Sermetacin; Sudoxicam; Sulindac; Suprofen; Talmetacin; Talniflumate; Talosalate; Tebufelone; Tenidap; Tenidap Sodium; Tenoxicam; Tesicam; Tesimide; Tetrydamine; Tiopinac; Tixocortol Pivalate; Tolmetin; Tolmetin Sodium; Triclonide; Triflumidate; Zidometacin; Zomepirac Sodium.

[00989] Antipsychotic and antineurotic drugs that can be used to alleviate psychiatric side effects in the methods of the invention include any and all selective serotonin receptor inhibitors (SSRIs) and other anti-depressants, anxiolytics (e.g. alprazolam), etc. Anti-depressants include, but are not limited to, serotonin reuptake inhibitors such as Celexa®,

Desyrel®, Effexor®, Luvox®, Paxil®, Prozac®, Zoloft®, and Serzone®; tricyclics such as Adapin®, Anafrinil®, Elavil®, Janimmune®, Ludiomil®, Pamelor®, Tofranil®, Vivactil®, Sinequan®, and Surmontil®; monoamine oxidase inhibitors such as Eldepryl®, Marplan®, Nardil®, and Parnate®. Anti-anxiety agents include, but are not limited to, azaspiroes such as BuSpar®, benzodiazepines such as Ativan®, Librium®, Tranxene®, Centrax®, Klonopin®, Paxipam®, Serax®, Valium®, and Xanax®; and beta-blockers such as Inderal® and Tenormin®.

[00990] Agents that reduce gastrointestinal discomfort such as nausea, diarrhea, gastrointestinal cramping, and the like are suitable palliative agents for use in a subject combination therapy. Suitable agents include, but are not limited to, antiemetics, anti-diarrheal agents, H2 blockers, antacids, and the like.

[00991] Suitable H2 blockers (histamine type 2 receptor antagonists) that are suitable for use as a palliative agent in a subject therapy include, but are not limited to, Cimetidine (e.g., Tagamet, Peptol, Nu-cimet, apo-cimetidine, non-cimetidine); Ranitidine (e.g., Zantac, Nu-ranit, Novo-randine, and apo-ranitidine); and Famotidine (Pepcid, Apo-Famotidine, and Novo-Famotidine).

[00992] Suitable antacids include, but are not limited to, aluminum and magnesium hydroxide (Maalox®, Mylanta®); aluminum carbonate gel (Basajel®); aluminum hydroxide (Amphojel®, AlternaGEL®); calcium carbonate (Tums®, Titalac®); magnesium hydroxide; and sodium bicarbonate.

[00993] Antiemetics include, but are not limited to, 5-hydroxytryptophan-3 (5HT3) inhibitors; corticosteroids such as dexamethasone and methylprednisolone; Marinol® (dronabinol); prochlorperazine; benzodiazepines; promethazine; and metoclopramide cisapride; Alosetron Hydrochloride; Batanopride Hydrochloride; Bemisetron; Benzquinamide; Chlorpromazine; Chlorpromazine Hydrochloride; Clebopride; Cyclizine Hydrochloride; Dimenhydrinate; Diphenidol; Diphenidol Hydrochloride; Diphenidol Pamoate; Dolasetron Mesylate; Domperidone; Dronabinol; Fludorex; Flumeridone; Galdansetron Hydrochloride; Granisetron; Granisetron Hydrochloride; Lurosetron Mesylate; Meclizine Hydrochloride; Metoclopramide Hydrochloride; Metopimazine; Ondansetron Hydrochloride; Pancopride; Prochlorperazine; Prochlorperazine Edisylate; Prochlorperazine Maleate; Promethazine Hydrochloride; Thiethylperazine; Thiethylperazine Malate; Thiethylperazine Maleate; Trimethobenzamide Hydrochloride; Zacropride Hydrochloride..

[00994] Anti-diarrheal agents include, but are not limited to, Rolgamidine, Diphenoxylate hydrochloride (Lomotil), Metronidazole (Flagyl), Methylprednisolone (Medrol), Sulfasalazine (Azulfidine), and the like.

[00995] Suitable hematopoietic agents that can be used to prevent or restore depressed blood cell populations in the methods of the invention include erythropoietins, such as EPOGEN™ epoetin-alfa, granulocyte colony stimulating factors (G-CSFs), such as NEUPOGEN™ filgrastim, granulocyte-macrophage colony stimulating factors (GM-CSFs), thrombopoietins, etc.

#### TREATMENT METHODS

[00996] The present invention provides a method of treating a disease, disorder, or condition in a patient. In one aspect, a subject treatment method utilizes an oral pharmaceutical formulation comprising a known hyperglycosylated, protease-resistant polypeptide variant of a parent protein therapeutic, the known protease-resistant polypeptide variant comprising at least one mutated protease cleavage site in place of a native protease cleavage site that is present in the parent protein therapeutic; and comprising: i) a carbohydrate moiety covalently attached to at least one non-native glycosylation site that is not present in the parent protein therapeutic; or ii) a carbohydrate moiety covalently attached to at least one native glycosylation site that is present but is not glycosylated in the parent protein therapeutic. The oral pharmaceutical composition is administered orally to the patient in an amount whereby the patient receives a first number of moles of the known hyperglycosylated, protease-resistant polypeptide variant at a first dosing interval. The first number of moles of the known hyperglycosylated, protease-resistant variant is greater than a second number of moles of the parent protein therapeutic in a parenteral pharmaceutical composition. The parenteral pharmaceutical composition is an immediate release formulation suitable for subcutaneous bolus injection, and the parent polypeptide is proven to be effective in the treatment of the disease, disorder or condition in the patient when administered to the patient by subcutaneous bolus injection in an amount of the parenteral pharmaceutical composition whereby the patient receives the second number of moles of the parent protein therapeutic at a second dosing interval. In a subject method of treating a disease in a patient, the method comprises administering orally to the patient the oral pharmaceutical composition in an amount whereby the patient receives the first number of moles of the known hyperglycosylated, protease-resistant polypeptide variant at the first dosing interval that is the same as or shorter than the second dosing interval.

[00997] Thus, the known hyperglycosylated, protease-resistant polypeptide variant is effective in the treatment of the disease, disorder or condition in a patient when administered to the patient orally at a dosage of the first number of moles at the first dosing interval for a desired treatment duration.

[00998] In another aspect, the invention provides a modification of the above-described method of treating a disease, disorder or condition in a patient, where the oral pharmaceutical composition comprising the known hyperglycosylated, protease-resistant polypeptide variant is administered orally to the patient in a first dose at a first dosing frequency, where the parenteral pharmaceutical composition is proven to be effective in the treatment of the disease in a patient when administered to the patient by subcutaneous bolus injection of a second dose of the parent protein therapeutic at a second dosing frequency, where the first dose in moles of the known hyperglycosylated, protease-resistant polypeptide variant per kilogram of patient body weight is greater than the second dose in moles of the parent protein therapeutic per kilogram of patient body weight when the first and second doses are calculated for the same patient body weight, and where upon oral administration of the first dose of the known hyperglycosylated, protease-resistant polypeptide variant to the patient, all of the known hyperglycosylated, protease-resistant polypeptide variant in the first dose is released in a period of time no greater than the period of time between doses in the second dosing frequency. In some embodiments, the parenteral pharmaceutical composition is proven to be effective in the treatment of the disease, disorder or condition in the patient when administered to the patient in a weight-based dose of the parent protein therapeutic at the second dosing interval, i.e., the second dose is a weight-based dose and the parenteral pharmaceutical composition is in a form that allows weight-based dosing. In some of the foregoing embodiments, the first dose is a weight-based dose of the known hyperglycosylated, protease-resistant polypeptide variant and the oral pharmaceutical composition is in a form that allows weight-based dosing.

[00999] In another aspect, the invention provides a modification of the above-described method of treating a disease, disorder or condition in a patient, where the oral pharmaceutical composition comprising the known hyperglycosylated, protease-resistant polypeptide variant is administered orally to the patient in a first dose at a first dosing frequency, where the parenteral pharmaceutical composition is proven to be effective in the treatment of the disease, disorder or condition in a patient when administered to the patient by subcutaneous bolus injection of a second dose of the parent protein therapeutic at a second dosing frequency, where the first dose in moles of the known hyperglycosylated, protease-resistant polypeptide variant per kilogram of patient body weight is greater than the second dose in moles of the parent protein therapeutic per kilogram of patient body weight when the first and second doses are calculated for the same patient body weight, and where the time period between doses in the first dosing frequency is the same as or shorter than the time period between doses in the

second dosing frequency. In some embodiments, the parenteral pharmaceutical composition is proven to be effective in the treatment of the disease, disorder or condition in the patient when administered to the patient in a weight-based dose of the parent protein therapeutic at the second dosing interval, i.e., the second dose is a weight-based dose and the parenteral pharmaceutical composition is in a form that allows weight-based dosing. In some of the foregoing embodiments, the first dose is a weight-based dose and the oral pharmaceutical composition is in a form that allows weight-based dosing.

[001000] The choice of hyperglycosylated, protease-resistant polypeptide variant will depend in part on the disease, disorder, or condition being treated. As noted above, the desired hyperglycosylated, protease-resistant polypeptide variant is effective to treat the disease, disorder, or condition that is treatable with a parent protein therapeutic. The following are non-limiting examples.

*Treatment Methods Using IFN- $\alpha$*

[001001] In one aspect, where the known hyperglycosylated, protease-resistant polypeptide variant is a known hyperglycosylated, protease-resistant IFN- $\alpha$ , a subject method provides for administering to an individual in need thereof a therapeutically effective amount of a known hyperglycosylated, protease-resistant IFN- $\alpha$  in a method of treating a viral infection, e.g., a hepatitis C virus (HCV) infection. In some embodiments, the method generally comprises orally administering a known hyperglycosylated, protease-resistant polypeptide variant of a parent IFN- $\alpha$  2 to an individual in need thereof in a first dose at a first dosing frequency that is at least as frequent, or more frequent, than a second dosing frequency proven to be effective in a regimen for treatment of HCV infection comprising administering to an individual in need thereof a parenteral formulation of the parent IFN- $\alpha$  2 in a second dose at the second dosing frequency, where the first dose comprises a first number of moles of the known hyperglycosylated, protease-resistant polypeptide variant that is greater than a second number of moles of the parent IFN- $\alpha$  2 in the second dose.

[001002] In one non-limiting example, the parent IFN- $\alpha$  2 is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof 3 million units (or 15 micrograms) of IFN- $\alpha$  2 by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent IFN- $\alpha$  2 can be, e.g., selected from the group of the [D99N]IFN- $\alpha$  2a, [D99N, D105N]IFN- $\alpha$  2a, [D99N]IFN- $\alpha$  2b, and [D99N, D105N]IFN- $\alpha$  2b glycopeptide variants (where the amino acid numbering is as set forth in Figure 24); where the variant further comprises one or more single amino acid

replacements at one or more target positions corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159 (where the amino acid numbering is as set forth in Figure 2), or any of the mutations depicted in Table 1, such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\alpha$  2. The variant is administered orally to the patient in the first dose containing the first number of moles of the variant at the first dosing frequency, where the first number of moles is greater than the number of moles of the parent IFN- $\alpha$  2 in 3 million units (or 15 micrograms) of the parent IFN- $\alpha$  2, and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

[001003] In some embodiments, the invention provides any of the foregoing methods of treating HCV infection with a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of IFN- $\alpha$  2, in which the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any of the carrier peptides described in Table 9 above in a covalent or non-covalent association with the desired polypeptide variant. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any such carrier peptide in a direct or indirect covalent linkage with the desired polypeptide variant, including without limitation any such carrier peptide fused to the N-terminus of the desired polypeptide variant.

[001004] In another non-limiting example, the parent IFN- $\alpha$  2 is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof 15 micrograms (or  $8.0 \times 10^{-10}$  mol.) of IFN- $\alpha$  2 by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent IFN- $\alpha$  2 can be, e.g., selected from the group of the [D99N]IFN- $\alpha$  2a, [D99N, D105N]IFN- $\alpha$  2a, [D99N]IFN- $\alpha$  2b, and [D99N, D105N]IFN- $\alpha$  2b glycopeptide variants (where the amino acid numbering is as set forth in Figure 24); where the variant further comprises one or more single amino acid replacements at one or more target positions corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159 (where the amino acid numbering is as set forth in Figure 2), or any of the mutations depicted in Table 1, such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\alpha$  2; and the variant is administered orally to the patient in the first dose containing the first number of moles of the variant at the first dosing frequency, where the first number of moles is greater than  $8.0 \times 10^{-10}$  mol., or at least about  $1.6 \times 10^{-9}$  mol., or at least about  $2.4 \times$



$10^{-9}$  mol., or at least about  $3.2 \times 10^{-9}$  mol., or at least about  $4.0 \times 10^{-9}$  mol., or at least about  $4.8 \times 10^{-9}$  mol., or at least about  $5.6 \times 10^{-9}$  mol., or at least about  $6.4 \times 10^{-9}$  mol., or at least about  $7.2 \times 10^{-9}$  mol., or at least about  $8.0 \times 10^{-9}$  mol., or at least about  $8.0 \times 10^{-8}$  mol., and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

[001005] In another aspect, where the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a known protease-resistant or protease-resistant, hyperglycosylated consensus IFN- $\alpha$ , a subject method provides for administering to an individual in need thereof a therapeutically effective amount of the known protease-resistant or protease-resistant, hyperglycosylated consensus IFN- $\alpha$  in a method of treating a viral infection, e.g., a hepatitis C virus (HCV) infection. In some embodiments, the method generally comprises orally administering a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent consensus IFN- $\alpha$  to an individual in need thereof in a first dose and at a first dosing frequency that is at least as frequent, or more frequent, than a second dosing frequency proven to be effective in a regimen for treatment of HCV infection comprising administering to an individual in need thereof a parenteral formulation of the parent consensus IFN- $\alpha$  in a second dose at the second dosing frequency, where the first dose comprises a first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant that is greater than a second number of moles of the parent consensus IFN- $\alpha$  in the second dose.

[001006] In one non-limiting example, the parent interferon alfacon-1 is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof 9 million units (or 9 micrograms) of INFERGEN® interferon alfacon-1 by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent interferon alfacon-1 can be, e.g., selected from the group of the [D99N]interferon alfacon-1, [D99N, D105N]interferon alfacon-1, [D99N, D105N, E134N]interferon alfacon-1, [D105N, E134N]interferon alfacon-1, [E134N]interferon alfacon-1, and [D99N, E134N]interferon alfacon-1 glycopeptides (where the amino acid numbering is as set forth in Figure 24); where the glycopeptide further comprises one or more single amino acid replacements at one or more target positions corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159 (where the amino acid numbering is as set forth in Figure 9), such that the variant comprises at least one mutated protease cleavage site in place

of a native protease cleavage site found in the parent consensus IFN- $\alpha$ ; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than the number of moles of interferon alfacon-1 in 9 million units (or 9 micrograms) of interferon alfacon-1, and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

[001007] In another non-limiting example, the parent interferon alfacon-1 is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof 15 million units (or 15 micrograms) of INFERGEN® interferon alfacon-1 by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent interferon alfacon-1 can be, e.g., selected from the group of the [D99N]interferon alfacon-1, [D99N, D105N]interferon alfacon-1, [D99N, D105N, E134N]interferon alfacon-1, [D105N, E134N]interferon alfacon-1, [E134N]interferon alfacon-1, and [D99N, E134N]interferon alfacon-1 glycopeptides (where the amino acid numbering is as set forth in Figure 24); where the glycopeptide further comprises one or more single amino acid replacements at one or more target positions corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159 (where the amino acid numbering is as set forth in Figure 9), such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent consensus IFN- $\alpha$ ; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than the number of moles of interferon alfacon-1 in 15 million units (or 15 micrograms) of interferon alfacon-1, and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

[001008] In another non-limiting example, the parent interferon alfacon-1 is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof 9 micrograms (or  $4.6 \times 10^{-10}$  mol.) of interferon alfacon-1 by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent

interferon alfacon-1 can be, e.g., selected from the group of the [D99N]interferon alfacon-1, [D99N, D105N]interferon alfacon-1, [D99N, D105N, E134N]interferon alfacon-1, [D105N, E134N]interferon alfacon-1, [E134N]interferon alfacon-1, and [D99N, E134N]interferon alfacon-1 glycopeptides (where the amino acid numbering is as set forth in Figure 24); where the glycopeptide further comprises one or more single amino acid replacements at one or more target positions corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159 (where the amino acid numbering is as set forth in Figure 9), such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent consensus IFN- $\alpha$ ; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than  $4.6 \times 10^{-10}$  mol., or at least about  $9.2 \times 10^{-10}$  mol., or at least about  $1.4 \times 10^{-9}$  mol., or at least about  $1.8 \times 10^{-9}$  mol., or at least about  $2.3 \times 10^{-9}$  mol., or at least about  $2.8 \times 10^{-9}$  mol., or at least about  $3.2 \times 10^{-9}$  mol., or at least about  $3.7 \times 10^{-9}$  mol., or at least about  $4.1 \times 10^{-9}$  mol., or at least about  $4.6 \times 10^{-9}$  mol., or at least about  $4.6 \times 10^{-8}$  mol., and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

**[001009]** In another non-limiting example, the parent interferon alfacon-1 is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof 15 micrograms (or  $7.6 \times 10^{-10}$  mol.) of interferon alfacon-1 by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent interferon alfacon-1 can be, e.g., selected from the group of the [D99N]interferon alfacon-1, [D99N, D105N]interferon alfacon-1, [D99N, D105N, E134N]interferon alfacon-1, [D105N, E134N]interferon alfacon-1, [E134N]interferon alfacon-1, and [D99N, E134N]interferon alfacon-1 glycopeptides, where the glycopeptide further comprises one or more single amino acid replacements at one or more target positions corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159, such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent consensus IFN- $\alpha$ ; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than  $7.6 \times 10^{-10}$  mol., or at least about  $1.5 \times 10^{-9}$  mol., or at least about  $2.3 \times 10^{-9}$  mol., or at least about  $3.0 \times$

$10^{-9}$  mol., or at least about  $3.8 \times 10^{-9}$  mol., or at least about  $4.6 \times 10^{-9}$  mol., or at least about  $5.3 \times 10^{-9}$  mol., or at least about  $6.1 \times 10^{-9}$  mol., or at least about  $6.8 \times 10^{-9}$  mol., or at least about  $7.6 \times 10^{-9}$  mol., or at least about  $7.6 \times 10^{-8}$  mol., and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

**[001010]** In another non-limiting example, the parent interferon alfacon-1 is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof 9 micrograms (or  $4.5 \times 10^{-8}$  mol.) of interferon alfacon-1 by subcutaneous bolus injection once per day for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent interferon alfacon-1 can be, e.g., selected from the group of the [D99N]interferon alfacon-1, [D99N, D105N]interferon alfacon-1, [D99N, D105N, E134N]interferon alfacon-1, [D105N, E134N]interferon alfacon-1, [E134N]interferon alfacon-1, and [D99N, E134N]interferon alfacon-1 glycopeptides, where the glycopeptide further comprises one or more single amino acid replacements at one or more target positions corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159, such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent consensus IFN- $\alpha$ ; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than  $4.6 \times 10^{-10}$  mol., or at least about  $9.2 \times 10^{-10}$  mol., or at least about  $1.4 \times 10^{-9}$  mol., or at least about  $1.8 \times 10^{-9}$  mol., or at least about  $2.3 \times 10^{-9}$  mol., or at least about  $2.8 \times 10^{-9}$  mol., or at least about  $3.2 \times 10^{-9}$  mol., or at least about  $3.7 \times 10^{-9}$  mol., or at least about  $4.1 \times 10^{-9}$  mol., or at least about  $4.6 \times 10^{-9}$  mol., or at least about  $4.6 \times 10^{-8}$  mol., and where the first dosing frequency is at least once per day. Alternatively, the first dosing frequency is twice per day or three times per day.

**[001011]** In another non-limiting example, the parent interferon alfacon-1 is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof 15 micrograms (or  $7.5 \times 10^{-8}$  mol.) of interferon alfacon-1 by subcutaneous bolus injection once per day for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent interferon alfacon-1 can be, e.g., selected from the group of the [D99N]interferon alfacon-1, [D99N, D105N]interferon alfacon-1, [D99N, D105N, E134N]interferon alfacon-1, [D105N, E134N]interferon alfacon-1, [E134N]interferon alfacon-1, and [D99N, E134N]interferon alfacon-1 glycopeptides, where the glycopeptide further comprises one or more single amino

acid replacements at one or more target positions corresponding to any of amino acid positions: 41, 58, 78, 107, 117, 125, 133 and 159, such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent consensus IFN- $\alpha$ ; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than  $7.6 \times 10^{-10}$  mol., or at least about  $1.5 \times 10^{-9}$  mol., or at least about  $2.3 \times 10^{-9}$  mol., or at least about  $3.0 \times 10^{-9}$  mol., or at least about  $3.8 \times 10^{-9}$  mol., or at least about  $4.6 \times 10^{-9}$  mol., or at least about  $5.3 \times 10^{-9}$  mol., or at least about  $6.1 \times 10^{-9}$  mol., or at least about  $6.8 \times 10^{-9}$  mol., or at least about  $7.6 \times 10^{-9}$  mol., or at least about  $7.6 \times 10^{-8}$  mol., and where the first dosing frequency is at least once per day. Alternatively, the first dosing frequency is twice per day or three times per day.

[001012] In some embodiments, the invention provides any of the foregoing methods of treating HCV infection with a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a consensus IFN- $\alpha$ , in which the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any of the carrier peptides described in Table 9 above in a covalent or non-covalent association with the desired polypeptide variant. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any such carrier peptide in a direct or indirect covalent linkage with the desired polypeptide variant, including without limitation any such carrier peptide fused to the N-terminus of the desired polypeptide variant.

#### *Treatment Methods Using IFN- $\gamma$*

[001013] In another aspect, where the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a hyperglycosylated IFN- $\gamma$ , a subject method provides for administering to an individual in need thereof a therapeutically effective amount of a known protease-resistant or protease-resistant, hyperglycosylated IFN- $\gamma$  in a method of treating a viral infection, e.g., an HCV infection. In some embodiments, the method generally comprises orally administering a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent IFN- $\gamma$  to an individual in need thereof in a first dose at a first dosing frequency that is at least as frequent, or more frequent, than a second dosing frequency proven to be effective in a regimen for treatment of HCV infection comprising administering to an individual in need thereof a therapeutically effective amount of an IFN- $\alpha$  and co-administering to the individual a parenteral formulation of the parent IFN- $\gamma$  in a second dose at the second dosing frequency, where the first dose comprises a first number of

moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant that is greater than a second number of moles of the parent IFN- $\gamma$  in the second dose.

[001014] In one non-limiting example, the parent IFN- $\gamma$  is IFN- $\gamma$  1b and is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof a therapeutically effective amount of an IFN- $\alpha$  and co-administering to the patient 100 micrograms ( $6.0 \times 10^{-9}$  mol.) of IFN- $\gamma$  1b by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent IFN- $\gamma$  1b can be, e.g., selected from the group of the [S99T]IFN- $\gamma$ , [E38N]IFN- $\gamma$ , [E38N, S40T]IFN- $\gamma$ , [E38N, S99T]IFN- $\gamma$ , and [E38N, S40T, S99T]IFN- $\gamma$  glycopeptides, where the glycopeptide variant further comprises one or more of the amino acid replacements set forth in Table 3 (IFN- $\gamma$ ), such that the glycopeptide variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than the number of moles of IFN- $\gamma$  1b in 100 micrograms ( $6.0 \times 10^{-9}$  mol.) of IFN- $\gamma$  1b, and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

[001015] In another non-limiting example, the parent IFN- $\gamma$  is IFN- $\gamma$  1b and is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof a therapeutically effective amount of an IFN- $\alpha$  and co-administering to the patient 50 micrograms ( $3.0 \times 10^{-9}$  mol.) of IFN- $\gamma$  1b by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent IFN- $\gamma$  1b can be, e.g., selected from the group of the [S99T]IFN- $\gamma$ , [E38N]IFN- $\gamma$ , [E38N, S40T]IFN- $\gamma$ , [E38N, S99T]IFN- $\gamma$ , and [E38N, S40T, S99T]IFN- $\gamma$  glycopeptides, where the glycopeptide variant further comprises one or more of the amino acid replacements set forth in Table 3 (IFN- $\gamma$ ), such that the glycopeptide variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than the number of moles of IFN- $\gamma$  1b in 50 micrograms ( $3.0 \times 10^{-9}$  mol.) of IFN- $\gamma$  1b, and where the first dosing frequency

is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

[001016] In another non-limiting example, the parent IFN- $\gamma$  is IFN- $\gamma$  1b and is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof a therapeutically effective amount of an IFN- $\alpha$  and co-administering to the patient 100 micrograms ( $6.0 \times 10^{-9}$  mol.) of IFN- $\gamma$  1b by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent IFN- $\gamma$  1b can be, e.g., selected from the group of the [S99T]IFN- $\gamma$ , [E38N]IFN- $\gamma$ , [E38N, S40T]IFN- $\gamma$ , [E38N, S99T]IFN- $\gamma$ , and [E38N, S40T, S99T]IFN- $\gamma$  glycopeptides, where the glycopeptide variant further comprises one or more of the amino acid replacements set forth in Table 3 (IFN- $\gamma$ ), such that the glycopeptide variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than  $6.0 \times 10^{-9}$  mol., or at least about  $1.2 \times 10^{-8}$  mol., or at least about  $1.8 \times 10^{-8}$  mol., or at least about  $2.4 \times 10^{-8}$  mol., or at least about  $3.0 \times 10^{-8}$  mol., or at least about  $3.6 \times 10^{-8}$  mol., or at least about  $4.2 \times 10^{-8}$  mol., or at least about  $4.8 \times 10^{-8}$  mol., or at least about  $5.4 \times 10^{-8}$  mol., or at least about  $6.0 \times 10^{-8}$  mol., or at least about  $6.0 \times 10^{-7}$  mol., and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

[001017] In another non-limiting example, the parent IFN- $\gamma$  is IFN- $\gamma$  1b and is proven to be effective in the treatment of HCV infection in a method comprising administering to a patient in need thereof a therapeutically effective amount of an IFN- $\alpha$  and co-administering to the patient 50 micrograms ( $3.0 \times 10^{-9}$  mol.) of IFN- $\gamma$  1b by subcutaneous bolus injection three times per week for 48 weeks. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent IFN- $\gamma$  1b can be, e.g., selected from the group of the [S99T]IFN- $\gamma$ , [E38N]IFN- $\gamma$ , [E38N, S40T]IFN- $\gamma$ , [E38N, S99T]IFN- $\gamma$ , and [E38N, S40T, S99T]IFN- $\gamma$  glycopeptides, where the glycopeptide variant further comprises one or more of the amino acid replacements set forth in Table 3 (IFN- $\gamma$ ), such that the glycopeptide variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide; and

administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than  $3.0 \times 10^{-9}$  mol., or at least about  $6.0 \times 10^{-9}$  mol., or at least about  $9.0 \times 10^{-9}$  mol., or at least about  $1.2 \times 10^{-8}$  mol., or at least about  $1.5 \times 10^{-8}$  mol., or at least about  $1.8 \times 10^{-8}$  mol., or at least about  $2.1 \times 10^{-8}$  mol., or at least about  $2.4 \times 10^{-8}$  mol., or at least about  $2.7 \times 10^{-8}$  mol., or at least about  $3.0 \times 10^{-8}$  mol., or at least about  $3.0 \times 10^{-7}$  mol., and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

[001018] In some embodiments, the invention provides any of the foregoing methods of treating HCV infection with a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a IFN- $\gamma$ , in which the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any of the carrier peptides described in Table 9 above in a covalent or non-covalent association with the desired polypeptide variant. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any such carrier peptide in a direct or indirect covalent linkage with the desired polypeptide variant, including without limitation any such carrier peptide fused to the N-terminus of the desired polypeptide variant.

[001019] Therapeutically effective amounts of IFN- $\alpha$  suitable for use in the present methods of treating HCV infection with IFN- $\alpha$  and IFN- $\gamma$  combination therapy are provided in the methods for treating HCV infection with IFN- $\alpha$  therapy described under the heading "Treatment Methods Using IFN- $\alpha$ " above. In addition, therapeutically effective amounts of IFN- $\alpha$  suitable for use in the present methods of treating HCV infection with IFN- $\alpha$  and IFN- $\gamma$  combination therapy are provided in the methods for treating HCV infection with IFN- $\alpha$  and IFN- $\gamma$  combination therapy described in WO 03/030613.

[001020] In another aspect, where the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a hyperglycosylated IFN- $\gamma$ , a subject method provides for administering to an individual in need thereof a therapeutically effective amount of a known protease-resistant or protease-resistant, hyperglycosylated IFN- $\gamma$  in a method of treating a fibrotic disorder, e.g., a pulmonary fibrotic disorder or a liver fibrotic disorder. In some embodiments, the method generally comprises orally administering a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent IFN- $\gamma$  to an individual in need thereof in a first dose at a first dosing frequency that is at least as frequent, or more frequent, than a second dosing frequency proven to be effective in a regimen for treatment of



the fibrotic disorder comprising administering to an individual in need thereof a parenteral pharmaceutical formulation of the parent IFN- $\gamma$  in a second dose at the second dosing frequency, where the first dose comprises a first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant that is greater than a second number of moles of the parent IFN- $\gamma$  in the second dose.

**[001021]** In one non-limiting example, the parent IFN- $\gamma$  is IFN- $\gamma$  1b and is proven to be effective in the treatment of a fibrotic disorder in a method comprising administering to a patient in need thereof 200 micrograms ( $1.2 \times 10^{-8}$  mol.) of IFN- $\gamma$  1b by subcutaneous bolus injection three times per week for 1 year or more. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent IFN- $\gamma$  1b can be, e.g., selected from the group of the [S99T]IFN- $\gamma$ , [E38N]IFN- $\gamma$ , [E38N, S40T]IFN- $\gamma$ , [E38N, S99T]IFN- $\gamma$ , and [E38N, S40T, S99T]IFN- $\gamma$  glycopeptides, where the glycopeptide variant further comprises one or more of the amino acid replacements set forth in Table 3 (IFN- $\gamma$ ), such that the glycopeptide variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide; and administered orally to the patient in the first dose containing the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at the first dosing frequency, where the first number of moles is greater than  $1.2 \times 10^{-8}$  mol., or at least about  $2.4 \times 10^{-8}$  mol., or at least about  $3.6 \times 10^{-8}$  mol., or at least about  $4.8 \times 10^{-8}$  mol., or at least about  $6.0 \times 10^{-8}$  mol., or at least about  $7.2 \times 10^{-8}$  mol., or at least about  $8.4 \times 10^{-8}$  mol., or at least about  $9.6 \times 10^{-8}$  mol., or at least about  $1.1 \times 10^{-7}$  mol., or at least about  $1.2 \times 10^{-7}$  mol., or at least about  $1.0 \times 10^{-6}$  mol., and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency, where the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

**[001022]** In some embodiments, the invention provides any of the foregoing methods of treating a fibrotic disorder with a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of IFN- $\gamma$ , where the fibrotic disorder is a pulmonary fibrotic disorder, such as idiopathic pulmonary fibrosis, or a liver fibrotic disorder. In some of the subject methods of treating idiopathic pulmonary fibrosis, the patient has an initial forced vital capacity (FVC)  $\geq$  55% of the predicted normal FVC. In other methods of the invention for treating idiopathic pulmonary fibrosis, the patient has an initial carbon monoxide diffusing capacity (DL<sub>CO</sub>)  $\geq$  35% of the predicted normal DL<sub>CO</sub>. In still other methods of the invention for treating idiopathic pulmonary fibrosis, the patient has an initial forced vital capacity (FVC)  $\geq$  55% of

the predicted normal FVC and an initial carbon monoxide diffusing capacity ( $DL_{CO}$ )  $\geq 35\%$  of the predicted normal  $DL_{CO}$ .

[001023] In some embodiments, the invention provides any of the foregoing methods of treating a fibrotic disorder with a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of an IFN- $\gamma$ , in which the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any of the carrier peptides described in Table 9 above in a covalent or non-covalent association with the desired polypeptide variant. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any such carrier peptide in a direct or indirect covalent linkage with the desired polypeptide variant, including without limitation any such carrier peptide fused to the N-terminus of the desired polypeptide variant.

[001024] In some embodiments, the invention provides any of the foregoing methods of treating a disease in a patient with a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent IFN- $\gamma$  1b therapeutic, where the method is modified to use any protease-resistant variant of glycosylated native (wild-type) human IFN- $\gamma$  (described in WO 02/081507) as the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of the parent IFN- $\gamma$  1b therapeutic. In one non-limiting example, the protease-resistant variant of glycosylated native human IFN- $\gamma$  comprises one or more of the amino acid replacements set forth in Table 3 (IFN- $\gamma$ ), such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site in the parent IFN- $\gamma$  1b polypeptide.

*Treatment Methods Using IFN- $\beta$*

[001025] In some embodiments, where the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a known protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$ , a subject method provides for administering to an individual in need thereof a therapeutically effective amount of the known protease-resistant or protease-resistant, hyperglycosylated IFN- $\beta$  in a method of treating multiple sclerosis. The method generally comprises orally administering a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent IFN- $\beta$  to an individual in need thereof in a first dose at a first dosing frequency that is at least as frequent, or more frequent, than a second dosing frequency proven to be effective in a regimen for treatment of multiple sclerosis comprising administering to an individual in need thereof a parenteral formulation of the parent IFN- $\beta$  in a second dose at the second dosing frequency, where the first dose comprises a first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated

polypeptide variant that is greater than a second number of moles of the parent IFN- $\beta$  in the second dose.

[001026] In one non-limiting example, the parent IFN- $\beta$ 1 therapeutic is IFN- $\beta$ 1b and is proven to be effective in the treatment of multiple sclerosis in a method comprising administering to a patient in need thereof 0.25 mg (or  $1.35 \times 10^{-8}$  mol.) IFN- $\beta$ 1b (BETASERON®) by subcutaneous bolus injection every other day for the desired treatment duration. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a known protease-resistant variant of the active ingredient of AVONEX® IFN- $\beta$ 1a, (e.g., where the protease-resistant variant comprises one or more of the amino acid changes set forth in Table 2) and is administered orally to the patient in the first dose containing the first number of moles of the variant at the first dosing frequency, where the first number of moles is greater than  $1.35 \times 10^{-8}$  mol., or at least about  $2.7 \times 10^{-8}$  mol., or at least about  $4.0 \times 10^{-8}$  mol., or at least about  $5.4 \times 10^{-8}$  mol., or at least about  $6.75 \times 10^{-8}$  mol., or at least about  $8.1 \times 10^{-8}$  mol., or at least about  $9.45 \times 10^{-8}$  mol., or at least about  $1.1 \times 10^{-7}$  mol., or at least about  $1.2 \times 10^{-7}$  mol., or at least about  $1.35 \times 10^{-7}$  mol., or at least about  $1.35 \times 10^{-6}$  mol., and where the first dosing frequency is at least every other day. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

*Treatment Methods Using Erythropoietin (EPO)*

[001027] In some embodiments, where the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a known protease-resistant or protease-resistant, hyperglycosylated EPO, a subject method provides for administering to an individual in need thereof a therapeutically effective amount of a known protease-resistant or protease-resistant, hyperglycosylated EPO in a method of treating anemia. The method generally comprises orally administering a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent EPO to an individual in need thereof in a first dose at a first dosing frequency that is at least as frequent, or more frequent, than a second dosing frequency proven to be effective in a regimen for treatment of anemia comprising administering to an individual in need thereof a parenteral formulation of the parent EPO in a second dose at the second dosing frequency, where the first dose comprises a first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant that is greater than a second number of moles of the parent EPO in the second dose.

[001028] In one non-limiting example, the parent EPO is proven to be effective in the treatment of anemia in a method comprising administering to a patient in need thereof 100 Units (770

micrograms or  $2.5 \times 10^{-8}$  mol.) EPOGEN® epoetin alfa per kilogram of patient body weight by subcutaneous bolus injection three times per week for the desired treatment duration. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a protease-resistant variant of the active ingredient of ARANESP® darbepoetin alfa, (e.g., where the protease-resistant or protease-resistant, hyperglycosylated variant comprises one or more of the amino acid changes set forth in Table 4) and administered orally to the patient in the first dose containing the first number of moles of the variant at the first dosing frequency, where the first number of moles is the product of greater than  $2.5 \times 10^{-8}$  mol., or at least about  $5.0 \times 10^{-8}$  mol., or at least about  $7.5 \times 10^{-8}$  mol., or at least about  $1.0 \times 10^{-7}$  mol., or at least about  $1.25 \times 10^{-7}$  mol., or at least about  $1.5 \times 10^{-7}$  mol., or at least about  $1.75 \times 10^{-7}$  mol., or at least about  $2.0 \times 10^{-7}$  mol., or at least about  $2.25 \times 10^{-7}$  mol., or at least about  $2.5 \times 10^{-7}$  mol., or at least about  $2.5 \times 10^{-6}$  mol., per kilogram of the patient's body weight multiplied by the patient's body weight, and where the first dosing frequency is at least three times per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

[001029] In another non-limiting example, the parent EPO is proven to be effective in the treatment of anemia in a method comprising administering to a patient in need thereof 50 Units (385 micrograms or  $1.25 \times 10^{-8}$  mol.) EPOGEN® epoetin alfa per kilogram of patient body weight by subcutaneous bolus injection three times per week for the desired treatment duration. In some of these embodiments, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a known protease-resistant variant of the active ingredient of ARANESP® darbepoetin alfa, (e.g., where the protease-resistant or protease-resistant, hyperglycosylated variant comprises one or more of the amino acid changes set forth in Table 4) and is administered orally to the patient in the first dose containing the first number of moles of the variant at the first dosing frequency, where the first number of moles is the product of greater than  $1.25 \times 10^{-8}$  mol., or at least about  $2.5 \times 10^{-8}$  mol., or at least about  $3.75 \times 10^{-8}$  mol., or at least about  $5.0 \times 10^{-8}$  mol., or at least about  $6.25 \times 10^{-8}$  mol., or at least about  $7.5 \times 10^{-8}$  mol., or at least about  $8.75 \times 10^{-8}$  mol., or at least about  $1.0 \times 10^{-7}$  mol., or at least about  $1.125 \times 10^{-7}$  mol., or at least about  $1.25 \times 10^{-7}$  mol., or at least about  $1.25 \times 10^{-6}$  mol., per kilogram of the patient's body weight multiplied by the patient's body weight, and where the first dosing frequency is at least three time per week. Alternatively, the first dosing frequency is four times per week, five times per week, six times per week, once per day, twice per day, or three times per day.

**KITS AND CONTAINERS**

- [001030] The present invention provides a container comprising a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant. The invention further provides a kit comprising a formulation comprising a unit dosage form of a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in a container, and a label that provides instructions for use of the kit.
- [001031] Suitable containers include those adapted for administration by subcutaneous injection, including a syringe (for use with a needle), an injector pen, and the like. In some embodiments, a subject agonist is administered with a pen injector (e.g., a medication delivery pen), a number of which are known in the art. Exemplary devices which can be adapted for use in the present methods are any of a variety of pen injectors from Becton Dickinson, e.g., BD™ Pen, BD™ Pen II, BD™ Auto-Injector; a pen injector from Innoject, Inc.; any of the medication delivery pen devices discussed in U.S. Patent Nos. 5,728,074, 6,096,010, 6,146,361, 6,248,095, 6,277,099, and 6,221,053; and the like. The medication delivery pen can be disposable, or reusable and refillable. Also suitable for use is an Intraject® needle-free injection system (Aradigm Corp.).
- [001032] The invention further provides a drug delivery device comprising (e.g., pre-loaded with) a reservoir containing a liquid formulation that comprises a single dose of a subject glycosylated synthetic Type I interferon receptor polypeptide agonist. In some embodiments, the present invention provides a pre-filled syringe comprising a pharmaceutical composition comprising a subject glycosylated synthetic Type I interferon receptor polypeptide agonist.
- [001033] The present invention provides formulations comprising a subject glycosylated synthetic Type I interferon receptor polypeptide agonist and a glycosylated IFN- $\gamma$  in a single liquid formulation that is contained in a single reservoir, for use in a drug delivery device. In some aspects, the present invention provides a drug reservoir or other container containing a subject glycosylated synthetic Type I interferon receptor polypeptide agonist and a glycosylated IFN- $\gamma$  co-formulated in a liquid, wherein both the subject glycosylated synthetic Type I interferon receptor polypeptide agonist and glycosylated IFN- $\gamma$  are present in the formulation in an amount suitable for one dose each. The reservoir can be provided in any of a variety of forms, including, but not limited to, a cartridge, a syringe, a reservoir of a continuous delivery device, and the like.
- [001034] The invention further provides a drug delivery device comprising (e.g., pre-loaded with) a reservoir containing a liquid formulation that comprises a single dose of a subject glycosylated synthetic Type I interferon receptor polypeptide agonist and a single dose of

glycosylated IFN- $\gamma$ . Exemplary, non-limiting drug delivery devices include injections devices, such as pen injectors, needle/syringe devices, continuous delivery devices, and the like. Any of the dosage amounts, including synergistically effective amounts, described herein can be used in the pharmaceutical formulation, in the reservoir, or in the drug delivery device.

[001035] In some embodiments, the present invention provides a pre-filled syringe comprising a pharmaceutical composition comprising a subject glycosylated synthetic Type I interferon receptor polypeptide agonist, a glycosylated IFN- $\gamma$ , and a pharmaceutically acceptable excipient, where the subject glycosylated synthetic Type I interferon receptor polypeptide agonist and the glycosylated IFN- $\gamma$  are co-formulated.

[001036] In other embodiments, the present invention provides a syringe comprising (a) a first barrel pre-filled with a pharmaceutical composition comprising a subject glycosylated synthetic Type I interferon receptor polypeptide agonist; (b) a second barrel pre-filled with a pharmaceutical composition comprising a glycosylated IFN- $\gamma$ .

[001037] In some embodiments, the present invention provides a container comprising a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in a formulation suitable for oral delivery. Formulations suitable for oral delivery include liquid formulations, solid formulations (e.g., tablets, capsules, and the like), and semi-solid formulations (e.g., gels, gel capsules, etc.).

#### SUBJECTS SUITABLE FOR TREATMENT

[001038] The subject methods are suitable for treating individuals having, or susceptible to having, a variety of disorders. In many embodiments, the individual is a human.

##### *Fibrotic disorders*

[001039] The subject methods for treating fibrotic disorders are suitable for treatment of individuals diagnosed as having a fibrotic disorder. Fibrotic disorders include, but are not limited to, pulmonary fibrosis, including idiopathic pulmonary fibrosis (IPF) and pulmonary fibrosis from a known etiology, liver fibrosis, and renal fibrosis. Other exemplary fibrotic conditions include musculoskeletal fibrosis, cardiac fibrosis, post-surgical adhesions, scleroderma, glaucoma, and skin lesions such as keloids.

##### *Cancer*

[001040] Subjects suitable for treatment with a subject method for treating cancer include individuals having any type of cancer. Also suitable for treatment are individuals who have failed previous treatment for a cancer with a standard cancer chemotherapeutic agent. Also suitable for treatment are individuals who have been previously treated with a standard cancer chemotherapeutic agent, who initially responded to such treatment, and in whom the cancer

subsequently reappeared. Also suitable for treatment are individuals who failed to respond to treatment with another agent for treating cancer.

*HCV infection*

- [001041] Individuals who are to be treated according to the methods of the invention for treating an HCV infection include individuals who have been clinically diagnosed as infected with HCV. Individuals who are infected with HCV are identified as having HCV RNA in their blood, and/or having anti-HCV antibody in their serum.
- [001042] Individuals who are clinically diagnosed as infected with HCV include naïve individuals (e.g., individuals not previously treated for HCV, particularly those who have not previously received IFN- $\alpha$ -based and/or ribavirin-based therapy) and individuals who have failed prior treatment for HCV ("treatment failure" patients). Treatment failure patients include non-responders (i.e., individuals in whom the HCV titer was not significantly or sufficiently reduced by a previous treatment for HCV, e.g., a previous IFN- $\alpha$  monotherapy, a previous IFN- $\alpha$  and ribavirin combination therapy, or a previous pegylated IFN- $\alpha$  and ribavirin combination therapy); and relapsers (i.e., individuals who were previously treated for HCV, e.g., who received a previous IFN- $\alpha$  monotherapy, a previous IFN- $\alpha$  and ribavirin combination therapy, or a previous pegylated IFN- $\alpha$  and ribavirin combination therapy, whose HCV titer decreased, and subsequently increased).
- [001043] In particular embodiments of interest, individuals have an HCV titer of at least about  $10^5$ , at least about  $5 \times 10^5$ , or at least about  $10^6$ , or at least about  $2 \times 10^6$ , genome copies of HCV per milliliter of serum. The patient may be infected with any HCV genotype (genotype 1, including 1a and 1b, 2, 3, 4, 6, etc. and subtypes (e.g., 2a, 2b, 3a, etc.)), particularly a difficult to treat genotype such as HCV genotype 1 and particular HCV subtypes and quasispecies.
- [001044] Also of interest are HCV-positive individuals (as described above) who exhibit severe fibrosis or early cirrhosis (non-decompensated, Child's-Pugh class A or less), or more advanced cirrhosis (decompensated, Child's-Pugh class B or C) due to chronic HCV infection and who are viremic despite prior anti-viral treatment with IFN- $\alpha$ -based therapies or who cannot tolerate IFN- $\alpha$ -based therapies, or who have a contraindication to such therapies. In particular embodiments of interest, HCV-positive individuals with stage 3 or 4 liver fibrosis according to the METAVIR scoring system are suitable for treatment with the methods of the present invention. In other embodiments, individuals suitable for treatment with the methods of the instant invention are patients with decompensated cirrhosis with clinical manifestations, including patients with far-advanced liver cirrhosis, including those awaiting liver

transplantation. In still other embodiments, individuals suitable for treatment with the methods of the instant invention include patients with milder degrees of fibrosis including those with early fibrosis (stages 1 and 2 in the METAVIR, Ludwig, and Scheuer scoring systems; or stages 1, 2, or 3 in the Ishak scoring system.).

#### EXAMPLES

[001045] The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how to make and use the present invention, and are not intended to limit the scope of what the inventors regard as their invention nor are they intended to represent that the experiments below are all or the only experiments performed. Efforts have been made to ensure accuracy with respect to numbers used (e.g. amounts, temperature, etc.) but some experimental errors and deviations should be accounted for. Unless indicated otherwise, parts are parts by weight, molecular weight is weight average molecular weight, temperature is in degrees Celsius, and pressure is at or near atmospheric. Standard abbreviations may be used, e.g., bp, base pair(s); kb, kilobase(s); pl, picoliter(s); s or sec, second(s); min, minute(s); h or hr, hour(s); aa, amino acid(s); kb, kilobase(s); bp, base pair(s); nt, nucleotide(s); i.m., intramuscular(ly); i.p., intraperitoneal(ly); s.c., subcutaneous(ly); and the like.

Example 1: Construction of hybrid Type I interferon receptor polypeptide agonists with non-native glycosylation sites

[001046] Among Type I interferons, two interferon alpha subtypes (IFN alpha 2b and 14), IFN beta 1 and IFN Omega 1 are naturally glycosylated in mammalian cells (Figure 24). Figure 24 provides an amino acid sequence comparison of the amino acid sequences of Infergen (SEQ ID NO:\*\*) and Type I Interferon species (SEQ ID NOs:\*\*-\*\*\*) that have been reported to be glycosylated naturally. The amino acid residues where the glycosylations occur are labeled with bold outlined boxes. The asparagines residues are the anchoring site for N-link glycosylation and the threonine residue is the anchoring site for O-link glycosylation. The majority sequence is shown above (SEQ ID NO:\*\*).

[001047] Based on the high degree of amino acid sequence identity between Infergen and other Type I interferons, glycosylation sites were designed in Infergen on the basis of amino acid sequence alignment of Infergen with the naturally glycosylated type I interferons (Figure 25). Figure 25 provides an amino acid sequence comparison of the amino acid sequences of amino acids 61-120 of Infergen (SEQ ID NO:\*\*) and various embodiments of subject glycosylated mutants (SEQ ID NOs:\*\*-\*\*\*). Sites 1, 2 and 3 are examples of positions where glycosylation



sites are created. Only N-link glycosylation sites are generated at Sites 1 and 2. Both N-link and O-link glycosylation sites are generated at Site 3. N-linked and O-linked glycosylation sites were engineered into Infergen. N-linked glycosylation involves a unique oligosaccharide branch structure that is attached to an asparagine residue found in an Asn-X-Ser/Thr motif. O-linked glycosylation consists of an oligosaccharide chain or glycosaminoglycan chains added to the OH group of serine or threonine residues. A majority sequence is shown above (SEQ ID NO:\*\*).

### Experimental Design

[001048] *Designing an Infergen gene optimized for expression in human cells.* Currently, Infergen is produced in *E.coli* and therefore contains codons optimized for bacterial expression. Glycosylated Infergen must be generated in mammalian cell lines. To increase the protein expression level in mammalian cells, a new Infergen gene with human codon usage preference (Table 8) was designed and synthesized using the most frequent codon for each amino acid is selected (Figure 26). Figure 26 depicts an exemplary synthetic mammalian Infergen nucleic acid sequence (SEQ ID NOs:\*\* and \*\*) with preferred human codon usage. The open reading frame is indicated with translated Infergen amino acid sequence (SEQ ID NO:\*\*). Six pairs of complementary primers from A to F are shown in alternating italics and bold text. The upper sense strands of the primer pairs are identified with odd number and lower non-sense strands are identified with even number. In the region upstream of the start codon ATG, a short sequence of GCCACC, the Kozak consensus sequence, is designed to increase eukaryotic translation efficiency. Two tandem stop codons -- TAA and TGA -- are used to ensure complete termination of translation. Table 8 (above) provides human codon usage preference. From, "Molecular Cloning: A Laboratory Manual" Sambrook J. and Russell D. W. Third Edition (2001) Cold Spring Harbor Press.

[001049] *Strategies for construction of synthetic Mammalian Infergen gene.* Since the new Mammalian Infergen DNA sequence is synthetic rather than naturally occurring, chemical synthesis of the gene is the reasonable route of synthesis. Typically chemical synthesis of a gene involves the synthesis short oligonucleotides, their annealing, ligation and cloning into a plasmid. A total of 6 pairs of oligonucleotides were used to produce a synthetic mammalian Infergen gene (Figure 26).

[001050] Each pair of annealed primers has terminal sequence that allows it to anneal to the adjacent oligonucleotide. The 5' and 3' end of the synthetic gene contain Hind III and Eco RI restriction endonuclease sites, respectively, which allows ligation into the plasmid. Detailed sequence information of these primers is given (Table 11).

**Table 11: Sequences of primers for chemical gene synthesis of Mammalian Infergen.**

Primer	Sense	Sequence (in 5' to 3' orientation)
	Yes	[Phosp] AGCTTGCCACCATGTGCGACCTGCCCCAGACCCA CAGCCTGGGCAACCGCCGCGCCCTGATCCTGCTGGCCC AGATGCGCCGCATCAGCCCC (SEQ ID NO:**) )
	No	[Phosp] GCGGCGCATCTGGGCCAGCAGGATCAGGGCGCGGC GGTTGCCCAGGCTGTGGGTCTGGGGCAGGTCGCACAT GGTGGCA (SEQ ID NO:**) )
	Yes	[Phosp] TTCAGCTGCCTGAAGGACCGCCACGACTTCGGCTT CCCCAGGAGGAGTTTCGACGGCAACCAGTTCCAGAAG GCCCAGGCCATCAGCG (SEQ ID NO:**) )
	No	[Phosp] CCTGGGCCTTCTGGAAGTGGTTGCCGTCGAACTCC TCCTGGGGGAAGCCGAAGTCGTGGCGGTCCTTCAGGC AGCTGAAGGGGCTGAT (SEQ ID NO:**) )
	Yes	[Phosp] TGCTGCACGAGATGATCCAGCAGACCTTCAACCTGT TCAGCACCAAGGACAGCAGCGCCGCTGGGACGAGA GCCTGCTGGAGAAG (SEQ ID NO:**) )
	No	[Phosp] AGGCTCTCGTCCAGGCGGCGCTGCTGTCCTTGGTGC TGAACAGGTTGAAGGTCTGCTGGATCATCTCGTGC AGCACGCTGATGG (SEQ ID NO:**) )
	Yes	[Phosp] TTCTACACCGAGCTGTACCAGCAGCTGAACGACCTG GAGGCCTGCGTGATCCAGGAGGTGGGCGTGGAGGAG ACCCCCCTGATGAACGTGG (SEQ ID NO:**) )
	No	[Phosp] TCAGGGGGGTCTCCTCCACGCCCACCTCCTGGATCAC GCAGGCCTCCAGGTCGTTTCAGCTGCTGGTACAGCT CGGTGTAGAACTTCTCCAGC (SEQ ID NO:**) )
	Yes	[Phosp] ACAGCATCCTGGCCGTGAAGAAGTACTTCCAGCGCAT CACCCTGTACCTGACCGAGAAGAAGTACAGCCCCCT GCGCCTGGGAGGTGG (SEQ ID NO:**) )
	No	[Phosp] AGGCGCAGGGGCTGTACTTCTTCTCGGTCAGGTACAGG GTGATGCGCTGGAAGTACTTCTTTCACGGCCAGGA TGCTGTCCACGTTCA (SEQ ID NO:**) )
	Yes	[Phosp] TGC GCGCCGAGATCATGCGCAGCTTCAGCCTGAGCAC CAACCTGCAGGAGCGCCTGCGCCGCAAGGAGTAAT GAG (SEQ ID NO:**) )
	No	[Phosp] AATTCTCATTACTCCTTGCGGCGCAGGCGCTCCTGCA GGTTGGTGCTCAGGCTGAAGCTGCGCATGATCTCG GCGCGCACCACTCCC (SEQ ID NO:**) )

**[001051]** *Strategies for generating Mammalian Infergen glycosylation mutants.* The sequence changes needed to produce mammalian, glycosylation competent Infergen are minor and can be introduced into the synthetic gene by standard site directed mutagenesis techniques (Figure 27). Figure 27 depicts a comparison of the nucleic acid sequences of Mammalian Infergen (SEQ ID NO:\*\*) and glycosylated mutants thereof (SEQ ID NOs:\*\*-\*); with the majority sequence shown above (SEQ ID NO:\*\*) . The nucleotides that differ are shown in boxes. Codons used based on the preferred codon usage in mammals (Table 8). The nucleotides that differ from the majority sequence are shown in boxes.

[001052] Figure 28 depicts an amino acid sequence comparison of human Interferon beta 1 (SEQ ID NO:\*\*) and exemplary IFN- $\beta$ 1 glycosylated mutants (SEQ ID NOs:\*\*-\*); with the majority sequence (SEQ ID NO:\*\*) shown above. Sites 1 and 2 are the positions where glycosylation mutants are generated. In general, only N-linked glycosylation sites are created at Site 1. Both N-linked and O-linked glycosylation sites are generated at Site 2. The naturally occurring N-linked glycosylation sites in human IFN- $\beta$ 1 and mutants are shown in boxes.

[001053] Figure 29 depicts an amino acid sequence comparison of human Interferon omega-1 (SEQ ID NO:\*\*) and exemplary glycosylation mutants (SEQ ID NOs:\*\*-\*); with the majority sequence (SEQ ID NO:\*\*) shown above. Sites 1 and 2 are the positions where glycosylation mutants are generated. In general, only N-linked glycosylation sites are created at Site 1. Both N-linked and O-linked glycosylation sites are generated at Site 2. The naturally occurring N-linked glycosylation sites in human IFN- $\omega$ 1 and mutants are shown in boxes.

Example 2: Design, construction, expression and glycosylation sites generation of Mammalian Infergen fusion constructs with other Type I Interferon signal peptides

## Materials and Methods

### *Construction of fusion genes*

[001054] The amino acid alignments of Infergen, and exemplary Infergen fusion proteins, human Interferon Alpha 14 and Beta are shown in Figure 30. A two-step polymerase chain reaction strategy was designed to synthesize the fusion genes for the proposed fusion proteins. The primers used in the PCR reactions are listed in Table 12, below.

**Table 12**

Primer Name	Sequence (5' to 3')
IFNa14_Inner	GCCCTGGTGGTGCTGAGCTGCAAGAGCAGC-TGCAGCCTGGGCTGCGACCTGCCCCAGACCCACAGC (SEQ ID NO:1350)
IFNa14_Outer	TATAAAGCTTGCCACCATGGCCCTGCCCTTC-GCCCTGATGATGGCCCTGGTGGTGCTGAGCTGCAAG (SEQ ID NO:1351)
IFNb_Inner	GCCCTGCTGCTGTGCTTCAGCACCACCGCCC-TGAGCATGAGCTGCGACCTGCCCCAGACCCACAGC (SEQ ID NO:1352)
IFNb_Outer	TATAAAGCTTGCCACCATGACCAACAAGTGC-CTGCTGCAGATCGCCCTGCTGCTGTGCTTCAGCACC (SEQ ID NO:1353)
INFERGEN_End	TATAGAATTCTCATTACTCCTTGCGGCGCAGGCG (SEQ ID NO:1354)

[001055] The mammalian Infergen gene was synthesized and cloned into pcDNA3.1 (Invitrogen, Carlsbad, CA) plasmid and was used as template. For the first round PCR to generate fusion

Infergen gene with human Interferon Alpha 14 signal peptide, IFNa14\_Inner primer was combined with INFERGEN\_End primer to generate PCR templates for second round PCR that was carried out using IFNa14\_Outer primer in combination with INFERGEN\_END primer. The final PCR product was digested with both Hind III and EcoRI and cloned into predigested pcDNA3.1 vector. The same procedure was applied to generate Infergen gene with human Interferon Beta signal peptide except that IFNb\_Inner and Outer primers were used to replace IFNa14\_Inner and Outer primers, respectively.

*Transient transfection and Western Analysis*

[001056] The Cos-7 cell line was selected to transiently over-express Infergen. Fugene-6 (Roche Applied Science, Indianapolis, IN) was used as the transfection reagent and the manufacturer's protocol was followed. Three days after the transfection, conditioned media was collected, then filtered through 0.22  $\mu$ M Tissue Culture Filter Unit and concentrated with Centriplus YM-10 Centrifugal Filter Unit (Millipore, Billerica, MA). Protein concentrations were measured. The attached cells were collected and cell lysate made using conventional methods. Rabbit polyclonal antibodies made against *E.coli* over-expressed Infergen were used as primary antibodies in Western analysis.

*Site-directed Mutagenesis*

[001057] The locations of exemplary glycosylation sites in the two fusion Infergen proteins are shown in Figure 25. The QuikChange site-directed mutagenesis kit (Stratagene, La Jolla, CA) was used to generate these mutations.

**Results**

[001058] The fusion constructs were generated and the sequences confirmed. Figure 30 depicts an amino acid sequence alignment of Infergen (SEQ ID NO:\*\*), human IFN- $\alpha$ 14 (SEQ ID NO:\*\*), human IFN- $\beta$ 1 (SEQ ID NO:\*\*), and exemplary fusion proteins with human IFN- $\alpha$  14 and human IFN- $\beta$  signal peptides (SEQ ID NOs:\*\* and \*\*, respectively). The majority sequence is shown above (SEQ ID NO:\*\*).

[001059] The constructs were then transiently transfected into Cos-7 cells and the transfection results were analyzed with western blot using rabbit polyclonal antibodies against Infergen. The results are shown in Figure 32.

[001060] Figure 32 depicts Western blot analysis of the transient transfection results. Lanes 1-4 were loaded with conditioned media from Cos-7 cells transfected with a plasmid containing nucleotide sequences encoding: Infergen with IFN- $\alpha$ 14 signal peptide (lane 1); Infergen with IFN- $\beta$  signal peptide (lane 2); Infergen without signal peptide (lane 3); and  $\beta$ -galactosidase (lane 4). Lanes 5-8 were loaded with cell lysates of Cos-7 cells transfected with plasmids a

plasmid containing nucleotide sequences encoding: Infergen with IFN- $\alpha$ 14 signal peptide (lane 5); Infergen with IFN- $\beta$  signal peptide (lane 6); Infergen without signal peptide (lane 7); and  $\beta$ -galactosidase (lane 8). Lane 9 was loaded with 30 ng of Infergen, produced by *E. coli* and obtained from a commercial source.

[001061] The results showed that both fusion proteins expressed well and were mostly secreted by the cells into the conditioned media, while the Infergen without signal peptide expressed poorly and existed intracellularly. The two fusion genes were selected as templates for generation of glycosylation sites.

[001062] While the present invention has been described with reference to the specific embodiments thereof, it should be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation, material, composition of matter, process, process step or steps, to the objective, spirit and scope of the present invention. All such modifications are intended to be within the scope of the claims appended hereto.

## CLAIMS

What is claimed is:

1. An oral pharmaceutical composition comprising:

(a) a first number of moles of a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic in a first unit form, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent protein therapeutic, and further comprising: i) a carbohydrate moiety covalently attached to at least one non-native glycosylation site that is not present in the parent protein therapeutic; or ii) a carbohydrate moiety covalently attached to at least one native glycosylation site that is present but is not glycosylated in the parent protein therapeutic; and

(b) a pharmaceutical excipient suitable for oral delivery,

wherein the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in the first unit form is greater than a second number of moles of the parent protein therapeutic in a parenteral pharmaceutical composition, wherein the parenteral pharmaceutical composition is an immediate release formulation suitable for subcutaneous bolus injection;

wherein the parent protein therapeutic is proven to be effective in the treatment of a disease in a patient when administered to the patient by subcutaneous bolus injection of an amount of the parenteral pharmaceutical composition whereby the patient receives the second number of moles of the parent protein therapeutic at a selected dosing interval; and

wherein, upon oral administration of the first unit form to a patient, the time required for release of the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is no more than the time between doses in the selected dosing interval.

2. An oral pharmaceutical composition comprising:

(a) a first dose of a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic in a first unit form, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent

protein therapeutic, and further comprising: i) a carbohydrate moiety covalently attached to at least one non-native glycosylation site that is not present in the parent protein therapeutic; or ii) a carbohydrate moiety covalently attached to at least one native glycosylation site that is present but is not glycosylated in the parent protein therapeutic; and

(b) a pharmaceutical excipient suitable for oral delivery,

wherein the parent protein therapeutic is proven to be effective in the treatment of a disease in a patient when administered to the patient by subcutaneous bolus injection of a second dose of the parent protein therapeutic at a selected dosing interval;

wherein the amount of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in moles of drug per kilogram of patient body weight in the first dose is greater than the amount of parent protein therapeutic in moles of drug per kilogram of patient body weight in the second dose when the first and second doses are calculated for the average patient body weight in the total population of patients suffering from the disease; and

wherein, upon oral administration of the first dose in the first unit form to a patient, the time required for release of all of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in the first dose is no greater than the time between doses in the selected dosing interval.

3. An oral pharmaceutical composition comprising:

(a) a first number of moles of a known hyperglycosylated polypeptide variant of a parent protein therapeutic in a first unit form, the known hyperglycosylated polypeptide variant comprising: i) a carbohydrate moiety covalently attached to at least one non-native glycosylation site that is not present in the parent protein therapeutic; or ii) a carbohydrate moiety covalently attached to at least one native glycosylation site that is present but is not glycosylated in the parent protein therapeutic; and

(b) a pharmaceutical excipient suitable for oral delivery,

wherein the first number of moles of the known hyperglycosylated polypeptide variant in the first unit form is greater than a second number of moles of the parent protein therapeutic in a parenteral pharmaceutical composition, wherein the parenteral pharmaceutical composition is an immediate release formulation suitable for subcutaneous bolus injection;

wherein the parent protein therapeutic is proven to be effective in the treatment of a disease in a patient when administered to the patient by subcutaneous bolus injection of an

amount of the parenteral pharmaceutical composition whereby the patient receives the second number of moles of the parent protein therapeutic at a selected dosing interval; and

wherein, upon oral administration of the first unit form to a patient, the time required for release of the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is no more than the time between doses in the selected dosing interval.

4. An oral pharmaceutical composition comprising:

(a) a first dose of a known hyperglycosylated polypeptide variant of a parent protein therapeutic in a first unit form, the known hyperglycosylated polypeptide variant comprising: i) a carbohydrate moiety covalently attached to at least one non-native glycosylation site that is not present in the parent protein therapeutic; or ii) a carbohydrate moiety covalently attached to at least one native glycosylation site that is present but is not glycosylated in the parent protein therapeutic; and

(b) a pharmaceutical excipient suitable for oral delivery,

wherein the parent protein therapeutic is proven to be effective in the treatment of a disease in a patient when administered to the patient by subcutaneous bolus injection of a second dose of the parent protein therapeutic at a selected dosing interval;

wherein the amount of the known hyperglycosylated polypeptide variant in moles of drug per kilogram of patient body weight in the first dose is greater than the amount of parent protein therapeutic in moles of drug per kilogram of patient body weight in the second dose when the first and second doses are calculated for the average patient body weight in the total population of patients suffering from the disease; and

wherein, upon oral administration of the first dose in the first unit form to a patient, the time required for release of all of the known hyperglycosylated polypeptide variant in the first dose is no greater than the time between doses in the selected dosing interval.

5. The composition of claim 2 or 4, wherein the second dose is a fixed dose.

6. The composition of claim 2 or 4, wherein the second dose is a weight-based dose.

7. The composition of claim 2 or 4, wherein the second dose is a stratified dose.



8. The composition of any of claims 1-7, wherein the at least one non-native glycosylation site is an *N*-linked glycosylation site.

9. The composition of any of claims 1-7, wherein the at least one non-native glycosylation site is an *O*-linked glycosylation site.

10. The composition of any of claims 1-7, wherein the known protease-resistant or hyperglycosylated or protease-resistant, hyperglycosylated polypeptide variant comprises two non-native glycosylation sites not found in the parent protein therapeutic.

11. The composition of claim 10, wherein the known protease-resistant or hyperglycosylated or protease-resistant, hyperglycosylated polypeptide variant comprises a carbohydrate moiety covalently attached to the non-native glycosylation sites.

12. The composition of any of claims 1-11, wherein the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a known protease-resistant or protease-resistant, hyperglycosylated variant of a parent IFN- $\alpha$ .

13. The composition of claim 12, wherein the parent IFN- $\alpha$  is an IFN- $\alpha$  2.

14. The composition of claim 13, wherein the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is selected from [D99N] IFN- $\alpha$  2a, [D99N, D105N] IFN- $\alpha$  2a, [D99N] IFN- $\alpha$  2b, and [D99N, D105N] IFN- $\alpha$  2b glycopeptides, and wherein the variant comprises one or more amino acid replacements at any of amino acid positions 41, 58, 78, 107, 117, 125, 133 and 159, such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\alpha$  2 polypeptide.

15. The composition of claim 12, wherein the parent IFN- $\alpha$  is a consensus IFN- $\alpha$ .

16. The composition of claim 15, wherein the parent IFN- $\alpha$  is interferon alfacon-1.

17. The composition of claim 16, wherein the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is selected from the group consisting of the [D99N]interferon alfacon-1, [D99N, D105N]interferon alfacon-1, [D99N, D105N, E134N]interferon alfacon-1, [D105N, E134N]interferon alfacon-1, [E134N]interferon alfacon-1, and [D99N, E134N]interferon alfacon-1 glycopeptides, and wherein the variant comprises one or more amino acid replacements at any of amino acid positions 41, 58, 78, 107, 117, 125, 133 and 159, such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent consensus IFN- $\alpha$  polypeptide.

18. The composition of any of claims 1-11 wherein the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a known protease-resistant or protease-resistant, hyperglycosylated variant of a parent protein therapeutic that is IFN- $\gamma$ .

19. The composition of claim 18 wherein the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is selected from the group consisting of the [S99T]IFN- $\gamma$ , [E38N]IFN- $\gamma$ , [E38N, S40T]IFN- $\gamma$ , [E38N, S99T]IFN- $\gamma$ , and [E38N, S40T, S99T]IFN- $\gamma$  glycopeptides, and wherein the variant comprises one or more amino acid replacements shown in Table 3, such that the variant comprises at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent IFN- $\gamma$  polypeptide.

20. The composition of claim 18, wherein the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is a protease-resistant variant of glycosylated native (wild-type) human IFN- $\gamma$ .

21. The composition of any of claim 1-20 wherein the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises a carbohydrate moiety covalently attached at each glycosylation site in the polypeptide variant.

22. The composition of any of claims 1-21, wherein the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any carrier peptide selected from the group consisting of the carrier peptides of Table 9.

23. The composition of claim 22, wherein the carrier peptide is part of the covalent molecular structure of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant.

24. The composition of claim 23, wherein the carrier peptide is at or near the N-terminus of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant.

25. A method of treating a disease in a patient, the method comprising:  
administering orally to the patient an oral pharmaceutical composition comprising a first number of moles of a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic, in an amount whereby the patient receives the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at a first dosing interval, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent protein therapeutic, and further comprising: i) a carbohydrate moiety covalently attached to at least one non-native glycosylation site that is not present in the parent protein therapeutic; or ii) a carbohydrate moiety covalently attached to at least one native glycosylation site that is present but is not glycosylated in the parent protein therapeutic;

wherein the first number of moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant is greater than a second number of moles of the parent protein therapeutic in a parenteral pharmaceutical composition, wherein the parenteral pharmaceutical composition is an immediate release formulation suitable for subcutaneous bolus injection;

wherein the parent protein therapeutic is proven to be effective in the treatment of the disease in a patient when administered to the patient by subcutaneous bolus injection of an amount of the parenteral pharmaceutical composition whereby the patient receives the second number of moles of the parent protein therapeutic at a second dosing interval; and

wherein the first dosing interval is the same as or shorter than the second dosing interval.

26. A method of treating a disease in a patient, the method comprising:

administering orally to the patient an oral pharmaceutical composition comprising a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic, in an amount whereby the patient receives a first dose of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at a first dosing interval, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent protein therapeutic, and further comprising: i) a carbohydrate moiety covalently attached to at least one non-native glycosylation site that is not present in the parent protein therapeutic; or ii) a carbohydrate moiety covalently attached to at least one native glycosylation site that is present but is not glycosylated in the parent protein therapeutic;

wherein a parenteral pharmaceutical composition comprising the parent protein therapeutic is proven to be effective in the treatment of the disease in a patient when administered to the patient by subcutaneous bolus injection of an amount of the parenteral pharmaceutical composition whereby the patient receives a second dose of the parent protein therapeutic at a second dosing interval,

wherein the first dose in moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant per kilogram of patient body weight is greater than the second dose in moles of the parent protein therapeutic per kilogram of patient body weight when the first and second doses are calculated for the same patient body weight, and

wherein, upon oral administration of the first dose to the patient, the time required for release of all of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant in the first dose is no greater than the time between doses in the second dosing interval.

27. The method of claim 26, wherein the time period between doses in the first dosing interval is the same as or shorter than the time period between doses in the second dosing interval.

28. A method of treating a disease in a patient, the method comprising:  
administering orally to the patient an oral pharmaceutical composition comprising a known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant of a parent protein therapeutic, in an amount whereby the patient receives a first dose of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant at a

first dosing interval, the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprising at least one mutated protease cleavage site in place of a native protease cleavage site found in the parent protein, and further comprising: i) a carbohydrate moiety covalently attached to at least one non-native glycosylation site that is not present in the parent protein therapeutic; or ii) a carbohydrate moiety covalently attached to at least one native glycosylation site present in but not glycosylated in the parent protein therapeutic;

wherein a parenteral pharmaceutical composition comprising the parent protein therapeutic is proven to be effective in the treatment of the disease in a patient when administered to the patient by subcutaneous bolus injection in an amount whereby the patient receives a second dose of the parent protein therapeutic at a second dosing interval,

wherein the first dose in moles of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant per kilogram of patient body weight is greater than the second dose in moles of the parent protein therapeutic per kilogram of patient body weight when the first and second doses are calculated for the same patient body weight, and

wherein the time period between doses in the first dosing interval is the same as or shorter than the time period between doses in the second dosing interval.

29. The method of any of claims 26-28, wherein the second dose is a fixed dose.
30. The method of any of claims 26-28, wherein the second dose is a weight-based dose.
31. The method of any of claims 26-28, wherein the second dose is a stratified dose.
32. The method of any of claims 26-31, wherein the first dose is a weight-based dose.
33. The composition of any of claims 26-31, wherein the first dose is a fixed dose.

34. The method of any of claims 25-33, wherein the disease is that described in a claim selected from claims 1-22, and wherein the oral pharmaceutical composition is that described in the selected claim.

35. A method of treating a disease in a patient, wherein the disease is that described in a claim selected from claims 1-24, the method comprising administering orally to the patient an effective amount of the oral pharmaceutical composition described in the selected claim.

36. The method of any of claims 25-33, wherein the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant comprises any carrier peptide selected from the group consisting of the carrier peptides of Table 9.

37. The method of claim 36, wherein the carrier peptide is part of the covalent molecular structure of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant.

38. The method of claim 37, wherein the carrier peptide is at or near the N-terminus of the known protease-resistant or protease-resistant, hyperglycosylated polypeptide variant.

39. A synthetic Type I interferon receptor polypeptide agonist.

40. The Type I interferon receptor polypeptide agonist of claim 39, wherein the polypeptide agonist comprises at least one non-native glycosylation site.

41. The polypeptide agonist of claim 40 wherein the non-native glycosylation site is an *N*-linked glycosylation site.

42. The polypeptide agonist of claim 40 wherein the non-native glycosylation site is an *O*-linked glycosylation site.

43. The Type I interferon receptor polypeptide agonist of claim 39, wherein the polypeptide agonist comprises at least one mutated protease cleavage site in place of a native protease cleavage site.

44. The polypeptide agonist of claim 39 or 40 or 43 that is a hybrid Type I interferon receptor polypeptide agonist.

45. The polypeptide of claim 44 that is selected from interferon- $\alpha$ 2a (D99N), interferon- $\alpha$ 2a (D105N), and interferon- $\alpha$ 2a (D99N, D105N).

46. The polypeptide of claim 44 that is selected from interferon- $\alpha$ 2b (D99N), interferon- $\alpha$ 2b (D105N), and interferon- $\alpha$ 2b (D99N, D105N).

47. The polypeptide of claim 44 that is selected from interferon alphacon-1 (D99N), interferon alphacon-1 (D95N, D105N), interferon alphacon-1 (D99N, D105N, E134N), interferon alphacon-1 (D105N, E134N), interferon alphacon-1 (E134N), and interferon alphacon-1 (D99N, E134N).

48. The polypeptide agonist of claim 44, wherein the amino acid sequence of the polypeptide comprises discrete sub-sequences corresponding in amino acid identity and number to sub-sequences of different, naturally occurring Type I interferon receptor polypeptide agonists selected from interferon- $\alpha$ 2b, interferon- $\alpha$ 14, interferon- $\beta$ 1, and interferon- $\omega$ , where the amino acid sequence of the polypeptide agonist differs from the amino acid sequence of naturally occurring Type I interferon receptor polypeptide agonists interferon- $\alpha$ 2b, interferon- $\alpha$ 14, interferon- $\beta$ 1, and interferon- $\omega$ .

49. The polypeptide agonist of claim 39 or 40 or 43 that is a consensus Type I interferon receptor polypeptide agonist.

50. The polypeptide agonist of claim 49 wherein the polypeptide agonist comprises an amino acid sequence as set forth in SEQ ID Nos:9-19.

51. The polypeptide agonist of any of claims 39-50, wherein the polypeptide agonist is glycosylated.

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52. The polypeptide agonist of any of claims 39-44 or 48-50, wherein the polypeptide agonist is glycosylated at a non-native glycosylation site in the polypeptide agonist.

53. A polynucleotide comprising a nucleotide sequence encoding a synthetic Type I interferon receptor polypeptide agonist of any one of claims 39-50.

54. The polynucleotide of claim 53, wherein said synthetic type I interferon receptor polypeptide agonist comprises the amino acid sequence set forth in any one of SEQ ID Nos:9-19.

55. The polynucleotide of claim 53, wherein the polynucleotide comprises codons corresponding to human codon usage bias.

56. An expression vector comprising the polynucleotide of claim 53 operably linked to a promoter functional in a eukaryotic cell.

57. A host cell comprising the polynucleotide of claim 53.

58. A host cell comprising the expression vector of claim 56.

59. The host cell of claim 57 or 58, wherein the host cell is a eukaryotic cell.



[illegible]

**amino acid sequence of mature, human IFN- $\alpha$ 2b**

[illegible]

### Figure 3

**amino acid sequence of human IFN- $\beta$**

[illegible]

### Figure 4

human IFN- $\gamma$  amino acid sequence

[illegible]

[illegible]

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Figure 6

## amino acid sequence of human growth hormone

Phe	Pro	Thr	Ile	Pro	Leu	Ser	Arg	Leu	Phe	Asp	Asn	Ala	Met	Leu	Arg
1				5					10					15	
Ala	Arg	Arg	Leu	Tyr	Gln	Leu	Ala	Tyr	Asp	Thr	Tyr	Gln	Glu	Phe	Glu
			20					25					30		
Glu	Ala	Tyr	Ile	Leu	Lys	Glu	Gln	Lys	Tyr	Ser	Phe	Leu	Gln	Asn	Pro
		35					40					45			
Gln	Thr	Ser	Leu	Cys	Phe	Ser	Glu	Ser	Ile	Pro	Thr	Pro	Ser	Asn	Arg
	50					55				60					
Glu	Glu	Thr	Gln	Gln	Lys	Ser	Asn	Leu	Glu	Leu	Leu	Arg	Ile	Ser	Leu
65					70					75				80	
Leu	Leu	Ile	Gln	Ser	Trp	Leu	Glu	Pro	Val	Gln	Phe	Leu	Arg	Ser	Val
			85					90					95		
Phe	Ala	Asn	Ser	Leu	Val	Tyr	Gly	Ala	Ser	Asp	Ser	Asn	Val	Tyr	Asp
		100						105					110		
Leu	Leu	Lys	Asp	Leu	Glu	Glu	Gly	Ile	Gln	Thr	Leu	Met	Gly	Arg	Leu
		115					120					125			
Glu	Asp	Gly	Ser	Pro	Arg	Thr	Gly	Gln	Ile	Phe	Lys	Gln	Thr	Tyr	Ser
	130					135					140				
Lys	Phe	Asp	Thr	Asn	Ser	His	Asn	Asp	Asp	Ala	Leu	Leu	Lys	Asn	Tyr
145					150					155				160	
Gly	Leu	Leu	Tyr	Cys	Phe	Arg	Lys	Asp	Met	Asp	Lys	Val	Glu	Thr	Phe
				165					170					175	
Leu	Arg	Ile	Val	Gln	Cys	Arg	Ser	Val	Glu	Gly	Ser	Cys	Gly	Phe	
		180						185					190		

**amino acid sequence of human erythropoietin**

[illegible]

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Figure 8

## amino acid sequence of human GM-CSF

Ala	Pro	Ala	Arg	Ser	Pro	Ser	Pro	Ser	Thr	Gln	Pro	Trp	Glu	His	Val
1				5					10					15	
Asn	Ala	Ile	Gln	Glu	Ala	Arg	Arg	Leu	Leu	Asn	Leu	Ser	Arg	Asp	Thr
			20					25					30		
Ala	Ala	Glu	Met	Asn	Glu	Thr	Val	Glu	Val	Ile	Ser	Glu	Met	Phe	Asp
		35					40					45			
Leu	Gln	Glu	Pro	Thr	Cys	Leu	Gln	Thr	Arg	Leu	Glu	Leu	Tyr	Lys	Gln
		50				55					60				
Gly	Leu	Arg	Gly	Ser	Leu	Thr	Lys	Leu	Lys	Gly	Pro	Leu	Thr	Met	Met
65					70				75					80	
Ala	Ser	His	Tyr	Lys	Gln	His	Cys	Pro	Pro	Thr	Pro	Glu	Thr	Ser	Cys
				85					90					95	
Ala	Thr	Gln	Ile	Ile	Thr	Phe	Glu	Ser	Phe	Lys	Glu	Asn	Leu	Lys	Asp
			100					105					110		
Phe	Leu	Leu	Val	Ile	Pro	Phe	Asp	Cys	Trp	Glu	Pro	Val	Gln	Glu	
			115				120					125			



**amino acid sequence of consensus IFN- $\alpha$**

[illegible]

**amino acid sequence of human IFN- $\alpha$**

[illegible]

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Figure 11

amino acid sequence of IFN- $\alpha$ 2c

```

Cys Asp Leu Pro Gln Thr His Ser Leu Gly Ser Arg Arg Thr Leu Met
 1      5      10      15
Leu Leu Ala Gln Met Arg Arg Ile Ser Leu Phe Ser Cys Leu Lys Asp
 20      25      30
Arg Arg Asp Phe Gly Phe Pro Gln Glu Glu Phe Gly Asn Gln Phe Gln
 35      40      45
Lys Ala Glu Thr Ile Pro Val Leu His Glu Met Ile Gln Gln Ile Phe
 50      55      60
Asn Leu Phe Ser Thr Lys Asp Ser Ser Ala Ala Trp Asp Glu Thr Leu
 65      70      75      80
Leu Asp Lys Phe Tyr Thr Glu Leu Tyr Gln Gln Leu Asn Asp Leu Glu
 85      90      95
Ala Cys Val Ile Gln Gly Val Gly Val Thr Glu Thr Pro Leu Met Lys
100      105      110
Glu Asp Ser Ile Leu Ala Val Arg Lys Tyr Phe Gln Arg Ile Thr Leu
115      120      125
Tyr Leu Lys Glu Lys Lys Tyr Ser Pro Cys Ala Trp Glu Val Val Arg
130      135      140
Ala Glu Ile Met Arg Ser Phe Ser Leu Ser Thr Asn Leu Gln Glu Ser
145      150      155      160
Leu Arg Ser Lys Glu
165

```

[illegible]



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Figure 14

amino acid sequence of IFN- $\alpha$ 6

```

Cys Asp Leu Pro Gln Thr His Ser Leu Gly His Arg Arg Thr Met Met
1      5      10      15
Leu Leu Ala Gln Met Arg Arg Ile Ser Leu Phe Ser Cys Leu Lys Asp
20      25      30
Arg His Asp Phe Arg Phe Pro Gln Glu Glu Phe Asp Gly Asn Gln Phe
35      40      45
Gln Lys Ala Glu Ala Ile Ser Val Leu His Glu Val Ile Gln Gln Thr
50      55      60
Phe Asn Leu Phe Ser Thr Lys Asp Ser Ser Val Ala Trp Asp Glu Arg
65      70      75      80
Leu Leu Asp Lys Leu Tyr Thr Glu Leu Tyr Gln Gln Leu Asn Asp Leu
85      90      95
Glu Ala Cys Val Met Gln Glu Val Trp Val Gly Gly Thr Pro Leu Met
100      105      110
Asn Glu Asp Ser Ile Leu Ala Val Arg Lys Tyr Phe Gln Arg Ile Thr
115      120      125
Leu Tyr Leu Thr Glu Lys Lys Tyr Ser Pro Cys Ala Trp Glu Val Val
130      135      140
Arg Ala Glu Ile Met Arg Ser Phe Ser Ser Ser Arg Asn Leu Gln Glu
145      150      155      160
Arg Leu Arg Arg Lys Glu
165

```

[illegible]

**amino acid sequence of IFN- $\alpha$ 4b**

[illegible]



**amino acid sequence of IFN- $\alpha$ I**

[illegible]

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Figure 18

amino acid sequence of IFN- $\alpha$ J

```

-----
Cys Asp Leu Pro Gln Thr His Ser Leu Arg Asn Arg Arg Ala Leu Ile
1      5      10      15
Leu Leu Ala Gln Met Gly Arg Ile Ser Pro Phe Ser Cys Leu Lys Asp
20      25      30
Arg His Glu Phe Arg Phe Pro Glu Glu Glu Phe Asp Gly His Gln Phe
35      40      45
Gln Lys Thr Gln Ala Ile Ser Val Leu His Glu Met Ile Gln Gln Thr
50      55      60
Phe Asn Leu Phe Ser Thr Glu Asp Ser Ser Ala Ala Trp Glu Gln Ser
65      70      75      80
Leu Leu Glu Lys Phe Ser Thr Glu Leu Tyr Gln Gln Leu Asn Asp Leu
85      90      95
Glu Ala Cys Val Ile Gln Glu Val Gly Val Glu Glu Thr Pro Leu Met
100      105      110
Asn Glu Asp Phe Ile Leu Ala Val Arg Lys Tyr Phe Gln Arg Ile Thr
115      120      125
Leu Tyr Leu Met Glu Lys Lys Tyr Ser Pro Cys Ala Trp Glu Val Val
130      135      140
Arg Ala Glu Ile Met Arg Ser Phe Ser Phe Ser Thr Asn Leu Lys Lys
145      150      155      160
Gly Leu Arg Arg Lys Asp
165

```

### amino acid sequence of IFN- $\alpha$ H

[illegible]

### amino acid sequence of IFN- $\alpha$ F

[illegible]

[illegible]

**amino acid sequence of IFN-β1**

[illegible]



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Figure 24

	M	A	-	-	-	L	-	F	A	L	L	-	A	L	V	-	T	S	-	S	-	S	-	S	L	G	C	D	L	P	Q	T	H	S	L	G	S	R	R	Majority	
1	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	D	L	P	Q	T	H	S	L	G	N	R	R	Infergen
1	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	D	L	P	Q	T	H	S	L	G	S	R	R	h IFN Alpha 2b
1	M	A	-	-	-	L	P	F	A	L	M	M	A	L	V	V	L	S	C	K	S	S	C	S	L	G	C	N	L	S	Q	T	H	S	L	N	N	R	R	h IFN alpha 14	
1	M	T	N	K	C	L	L	Q	I	A	L	L	L	C	F	S	T	T	A	L	S	M	S	Y	N	L	L	G	F	L	Q	R	S	S	N	F	Q	C	Q	K	h IFN beta 1
1	M	A	-	-	-	L	L	F	P	L	L	A	A	L	V	M	T	S	Y	S	P	V	G	S	L	G	C	D	L	P	Q	N	H	G	L	L	S	R	N	h IFN Omega 1	
	T	L	M	L	L	A	Q	M	R	R	I	S	P	F	S	C	L	K	D	R	H	D	F	G	F	P	Q	E	E	F	D	G	N	Q	F	Q	K	A	Q	A	Majority
15	A	L	I	L	L	A	Q	M	R	R	I	S	P	F	S	C	L	K	D	R	H	D	F	G	F	P	Q	E	E	F	D	G	N	Q	F	Q	K	A	Q	A	Infergen
15	T	L	M	L	L	A	Q	M	R	R	I	S	L	F	S	C	L	K	D	R	H	D	F	G	F	P	Q	E	E	F	-	G	N	Q	F	Q	K	A	E	T	h IFN Alpha 2b
37	T	L	M	L	M	A	Q	M	R	R	I	S	P	F	S	C	L	K	D	R	H	D	F	E	F	P	Q	E	E	F	D	G	N	Q	F	Q	K	A	Q	A	h IFN alpha 14
41	-	-	L	L	W	Q	L	N	G	R	L	E	Y	-	C	L	K	D	R	M	N	F	D	I	P	E	E	I	K	Q	L	Q	Q	F	Q	K	E	D	A	h IFN beta 1	
37	T	L	V	L	L	H	Q	M	R	R	I	S	P	F	L	C	L	K	D	R	D	F	R	F	P	Q	E	M	V	K	G	S	Q	L	Q	K	A	H	V	h IFN Omega 1	
	I	S	V	L	H	E	M	L	Q	Q	I	F	N	L	F	S	T	K	D	S	S	A	A	W	D	E	T	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	Majority
55	I	S	V	L	H	E	M	I	Q	Q	T	F	N	L	F	S	T	K	D	S	S	A	A	W	D	E	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	Infergen
54	I	P	V	L	H	E	M	I	Q	Q	I	F	N	L	F	S	T	K	D	S	S	A	A	W	D	E	T	L	L	D	K	F	Y	T	E	L	Y	Q	Q	L	h IFN Alpha 2b
77	I	S	V	L	H	E	M	M	Q	Q	T	F	N	L	F	S	T	K	D	S	S	A	A	W	D	E	T	L	L	E	K	F	Y	T	E	L	F	Q	Q	M	h IFN alpha 14
77	A	L	T	I	Y	E	M	L	Q	N	I	F	A	I	F	R	Q	D	S	S	S	T	G	W	N	E	T	I	V	E	N	L	A	N	V	Y	H	Q	I	h IFN beta 1	
77	M	S	V	L	H	E	M	L	Q	Q	I	F	S	L	F	H	T	E	R	S	S	A	A	W	N	M	T	L	L	D	Q	L	H	T	G	L	H	Q	Q	L	h IFN Omega 1
	N	D	L	E	A	C	V	I	Q	E	V	G	V	E	E	T	P	L	M	N	E	D	S	I	L	A	V	K	K	Y	F	Q	R	I	T	L	Y	L	K	E	Majority
95	N	D	L	E	A	C	V	I	Q	E	V	G	V	E	E	T	P	L	M	N	V	D	S	I	L	A	V	K	K	Y	F	Q	R	I	T	L	Y	L	T	E	Infergen
94	N	D	L	E	A	C	V	I	Q	G	V	G	V	E	E	T	P	L	M	K	E	D	S	I	L	A	V	R	K	Y	F	Q	R	I	T	L	Y	L	K	E	h IFN Alpha 2b
117	N	D	L	E	A	C	V	I	Q	E	V	G	V	E	E	T	P	L	M	N	E	D	S	I	L	A	V	K	K	Y	F	Q	R	I	T	L	Y	L	M	E	h IFN alpha 14
117	N	H	L	K	T	V	L	E	E	K	L	E	K	E	D	F	T	R	G	K	L	M	S	S	L	H	L	K	R	Y	Y	G	R	I	L	H	Y	L	K	A	h IFN beta 1
117	Q	H	L	E	T	C	L	L	Q	V	V	G	E	G	E	S	A	G	A	I	S	S	P	A	L	T	L	R	R	Y	F	Q	G	I	R	V	Y	L	K	E	h IFN Omega 1
	K	K	Y	S	P	C	A	W	E	V	V	R	A	E	I	M	R	S	F	S	L	S	T	N	L	Q	E	R	L	R	S	K	D	-	-	-	-	-	-	Majority	
135	K	K	Y	S	P	C	A	W	E	V	V	R	A	E	I	M	R	S	F	S	L	S	T	N	L	Q	E	R	L	R	S	K	E	-	-	-	-	-	-	Infergen	
134	K	K	Y	S	P	C	A	W	E	V	V	R	A	E	I	M	R	S	F	S	L	S	T	N	L	Q	E	S	L	R	S	K	E	-	-	-	-	-	-	h IFN Alpha 2b	
157	K	K	Y	S	P	C	A	W	E	V	V	R	A	E	I	M	R	S	F	S	F	S	T	N	L	Q	K	R	L	R	S	K	D	-	-	-	-	-	-	h IFN alpha 14	
157	K	E	Y	S	H	C	A	W	T	I	V	R	V	E	I	L	R	N	F	Y	F	I	N	R	L	T	G	Y	L	R	N	-	-	-	-	-	-	-	h IFN beta 1		
157	K	K	Y	S	D	C	A	W	E	V	V	R	M	E	I	M	K	S	L	F	L	S	T	N	M	Q	E	R	L	R	S	K	D	R	D	L	G	S	S	h IFN Omega 1	



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Figure 25

	M	I	Q	Q	T	F	N	L	F	S	T	K	D	S	S	A	A	W	D	E	Majority
										70										80	
61	M	I	Q	Q	T	F	N	L	F	S	T	K	D	S	S	A	A	W	D	E	Infergen
61	M	I	Q	Q	T	F	N	L	F	S	T	K	N	S	S	A	A	W	D	E	Infergen D73N
61	M	I	Q	Q	T	F	N	L	F	S	T	K	D	S	S	A	A	W	N	E	Infergen D79N
61	M	I	Q	Q	T	F	N	L	F	S	T	K	D	S	S	A	A	W	D	E	Infergen E108T
61	M	I	Q	Q	T	F	N	L	F	S	T	K	D	S	S	A	A	W	D	E	Infergen E108N
61	M	I	Q	Q	T	F	N	L	F	S	T	K	N	S	S	A	A	W	N	E	Infergen D73N_D79N
61	M	I	Q	Q	T	F	N	L	F	S	T	K	N	S	S	A	A	W	D	E	Infergen D73N_E108T
61	M	I	Q	Q	T	F	N	L	F	S	T	K	N	S	S	A	A	W	N	E	Infergen D79N_E108T
61	M	I	Q	Q	T	F	N	L	F	S	T	K	N	S	S	A	A	W	D	E	Infergen D73N_E108N
61	M	I	Q	Q	T	F	N	L	F	S	T	K	N	S	S	A	A	W	N	E	Infergen D79N_E108N
61	M	I	Q	Q	T	F	N	L	F	S	T	K	N	S	S	A	A	W	N	E	Infergen D73N_D79N_E108T
61	M	I	Q	Q	T	F	N	L	F	S	T	K	N	S	S	A	A	W	N	E	Infergen D73N_D79N_E108N
	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Majority
										90										100	
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen D73N
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen D79N
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen E108T
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen E108N
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen D73N_D79N
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen D73N_E108T
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen D79N_E108T
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen D73N_E108N
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen D79N_E108N
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen D73N_D79N_E108T
81	S	L	L	E	K	F	Y	T	E	L	Y	Q	Q	L	N	D	L	E	A	C	Infergen D73N_D79N_E108N
	V	I	Q	E	V	G	V	T	E	T	P	L	M	N	V	D	S	I	L	A	Majority
										110										120	
101	V	I	Q	E	V	G	V	E	E	T	P	L	M	N	V	D	S	I	L	A	Infergen
101	V	I	Q	E	V	G	V	E	E	T	P	L	M	N	V	D	S	I	L	A	Infergen D73N
101	V	I	Q	E	V	G	V	E	E	T	P	L	M	N	V	D	S	I	L	A	Infergen D79N
101	V	I	Q	E	V	G	V	T	E	T	P	L	M	N	V	D	S	I	L	A	Infergen E108T
101	V	I	Q	E	V	G	V	N	E	T	P	L	M	N	V	D	S	I	L	A	Infergen E108N
101	V	I	Q	E	V	G	V	E	E	T	P	L	M	N	V	D	S	I	L	A	Infergen D73N_D79N
101	V	I	Q	E	V	G	V	T	E	T	P	L	M	N	V	D	S	I	L	A	Infergen D73N_E108T
101	V	I	Q	E	V	G	V	T	E	T	P	L	M	N	V	D	S	I	L	A	Infergen D79N_E108T
101	V	I	Q	E	V	G	V	N	E	T	P	L	M	N	V	D	S	I	L	A	Infergen D73N_E108N
101	V	I	Q	E	V	G	V	N	E	T	P	L	M	N	V	D	S	I	L	A	Infergen D79N_E108N
101	V	I	Q	E	V	G	V	T	E	T	P	L	M	N	V	D	S	I	L	A	Infergen D73N_D79N_E108T
101	V	I	Q	E	V	G	V	N	E	T	P	L	M	N	V	D	S	I	L	A	Infergen D73N_D79N_E108N

[illegible]

A G C A C A G C A G C G C C G C C T G G																		Majority				
230																		240				
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN D73N	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN D79N	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN E108N	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN E108T	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN D73N_D79N	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN D73N_E108N	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN D73N_E108T	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN D79N_E108N	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN D79N_E108T	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN D73N_D79N_E108N	
221	A	G	G	A	C	A	G	C	A	G	C	G	C	G	C	C	T	G	G	MAMMALIAN	INFERGEN D73N_D79N_E108T	
G A C G A G A G C C T G C T G G A G A A																		Majority				
250																		260				
241	G	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	MAMMALIAN	INFERGEN
241	G	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	MAMMALIAN	INFERGEN D73N
241	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	A	MAMMALIAN	INFERGEN D79N
241	G	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	MAMMALIAN	INFERGEN E108N
241	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	A	MAMMALIAN	INFERGEN E108T
241	G	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	MAMMALIAN	INFERGEN D73N_D79N
241	G	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	MAMMALIAN	INFERGEN D73N_E108N
241	G	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	MAMMALIAN	INFERGEN D73N_E108T
241	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	A	MAMMALIAN	INFERGEN D79N_E108N
241	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	A	MAMMALIAN	INFERGEN D79N_E108T
241	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	A	MAMMALIAN	INFERGEN D73N_D79N_E108N
241	A	C	G	A	G	A	G	C	C	T	G	C	T	G	G	A	G	A	A	A	MAMMALIAN	INFERGEN D73N_D79N_E108T
G T T C T A C A C C G A G C T G T A C C																		Majority				
270																		280				
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN D73N
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN D79N
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN E108N
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN E108T
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN D73N_D79N
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN D73N_E108N
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN D73N_E108T
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN D79N_E108N
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN D79N_E108T
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN D73N_D79N_E108N
261	G	T	T	C	T	A	C	A	C	C	G	A	G	C	T	G	T	A	C	C	MAMMALIAN	INFERGEN D73N_D79N_E108T
A G C A G C T G A A C G A C C T G G A G																		Majority				
290																		300				
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN D73N
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN D79N
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN E108N
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN E108T
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN D73N_D79N
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN D73N_E108N
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN D73N_E108T
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN D79N_E108N
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN D79N_E108T
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN D73N_D79N_E108N
281	A	G	C	A	G	C	T	G	A	A	C	G	A	C	C	T	G	G	A	G	MAMMALIAN	INFERGEN D73N_D79N_E108T
G C C T G C G T G A T C C A G G A G G T																		Majority				
310																		320				
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN D73N
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN D79N
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN E108N
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN E108T
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN D73N_D79N
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN D73N_E108N
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN D73N_E108T
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN D79N_E108N
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN D79N_E108T
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN D73N_D79N_E108N
301	G	C	C	T	G	C	G	T	G	A	T	C	C	A	G	G	A	G	G	T	MAMMALIAN	INFERGEN D73N_D79N_E108T
G G G C G T G A A C G A G A C C C C C C																		Majority				
330																		340				
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN D73N
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN D79N
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN E108N
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN E108T
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN D73N_D79N
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN D73N_E108N
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN D73N_E108T
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN D79N_E108N
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN D79N_E108T
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN D73N_D79N_E108N
321	G	G	G	C	G	T	G	A	A	G	A	G	A	C	C	C	C	C	C	C	MAMMALIAN	INFERGEN D73N_D79N_E108T

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Figure 28

Site 1																					Majority	
Y E M L Q N I F A I F R Q D S S S T G W																						
90															100							
81	Y	E	M	L	Q	N	I	F	A	I	F	R	Q	D	S	S	S	T	G	W	h IFN beta 1	
81	Y	E	M	L	Q	N	I	F	A	I	F	R	Q	D	N	S	S	T	G	W	h IFN beta 1_S95N	
81	Y	E	M	L	Q	N	I	F	A	I	F	R	Q	D	S	S	S	T	G	W	h IFN beta 1_E130T	
81	Y	E	M	L	Q	N	I	F	A	I	F	R	Q	D	S	S	S	T	G	W	h IFN beta 1_E130N_F132T	
81	Y	E	M	L	Q	N	I	F	A	I	F	R	Q	D	N	S	S	T	G	W	h IFN beta 1_S95N_E130T	
81	Y	E	M	L	Q	N	I	F	A	I	F	R	Q	D	N	S	S	T	G	W	h IFN beta 1_S95N_E130N_F132T	
Majority																						
N E T I V E N L L A N V Y H Q I N H L K																						
110															120							
101	N	E	T	I	V	E	N	L	L	A	N	V	Y	H	Q	I	N	H	L	K	h IFN beta 1	
101	N	E	T	I	V	E	N	L	L	A	N	V	Y	H	Q	I	N	H	L	K	h IFN beta 1_S95N	
101	N	E	T	I	V	E	N	L	L	A	N	V	Y	H	Q	I	N	H	L	K	h IFN beta 1_E130T	
101	N	E	T	I	V	E	N	L	L	A	N	V	Y	H	Q	I	N	H	L	K	h IFN beta 1_E130N_F132T	
101	N	E	T	I	V	E	N	L	L	A	N	V	Y	H	Q	I	N	H	L	K	h IFN beta 1_S95N_E130T	
101	N	E	T	I	V	E	N	L	L	A	N	V	Y	H	Q	I	N	H	L	K	h IFN beta 1_S95N_E130N_F132T	
Majority																						
T V L E E K L E K T D F T R G K L M S S																						
130															140							
121	T	V	L	E	E	K	L	E	K	E	D	F	T	R	G	K	L	M	S	S	h IFN beta 1	
121	T	V	L	E	E	K	L	E	K	E	D	F	T	R	G	K	L	M	S	S	h IFN beta 1_S95N	
121	T	V	L	E	E	K	L	E	K	T	D	F	T	R	G	K	L	M	S	S	h IFN beta 1_E130T	
121	T	V	L	E	E	K	L	E	K	N	D	T	R	G	K	L	M	S	S	S	h IFN beta 1_E130N_F132T	
121	T	V	L	E	E	K	L	E	K	T	D	F	T	R	G	K	L	M	S	S	h IFN beta 1_S95N_E130T	
121	T	V	L	E	E	K	L	E	K	N	D	T	R	G	K	L	M	S	S	S	h IFN beta 1_S95N_E130N_F132T	
Site 2																						

**Figure 29**

Site 1																					
H E M L Q Q I F S L F H T E N S S A A W																				Majority	
90										100											
81	H	E	M	L	Q	Q	I	F	S	L	F	H	T	E	R	S	S	A	A	W	h IFN Omega 1
81	H	E	M	L	Q	Q	I	F	S	L	F	H	T	E	N	S	S	A	A	W	h IFN Omega 1_R95N
81	H	E	M	L	Q	Q	I	F	S	L	F	H	T	E	R	S	S	A	A	W	h IFN Omega 1_G130T
81	H	E	M	L	Q	Q	I	F	S	L	F	H	T	E	R	S	S	A	A	W	h IFN Omega 1_G130N
81	H	E	M	L	Q	Q	I	F	S	L	F	H	T	E	N	S	S	A	A	W	h IFN Omega 1_R95N_G130N
81	H	E	M	L	Q	Q	I	F	S	L	F	H	T	E	N	S	S	A	A	W	h IFN Omega 1_R95N_G130T
N M T L L D Q L H T G L H Q Q L Q H L E																				Majority	
110										120											
101	N	M	T	L	L	D	Q	L	H	T	G	L	H	Q	Q	L	Q	H	L	E	h IFN Omega 1
101	N	M	T	L	L	D	Q	L	H	T	G	L	H	Q	Q	L	Q	H	L	E	h IFN Omega 1_R95N
101	N	M	T	L	L	D	Q	L	H	T	G	L	H	Q	Q	L	Q	H	L	E	h IFN Omega 1_G130T
101	N	M	T	L	L	D	Q	L	H	T	G	L	H	Q	Q	L	Q	H	L	E	h IFN Omega 1_G130N
101	N	M	T	L	L	D	Q	L	H	T	G	L	H	Q	Q	L	Q	H	L	E	h IFN Omega 1_R95N_G130N
101	N	M	T	L	L	D	Q	L	H	T	G	L	H	Q	Q	L	Q	H	L	E	h IFN Omega 1_R95N_G130T
T C L L Q V V G E G E S A G A I S S P A																				Majority	
130										140											
121	T	C	L	L	Q	V	V	G	E	G	E	S	A	G	A	I	S	S	P	A	h IFN Omega 1
121	T	C	L	L	Q	V	V	G	E	G	E	S	A	G	A	I	S	S	P	A	h IFN Omega 1_R95N
121	T	C	L	L	Q	V	V	G	E	T	E	S	A	G	A	I	S	S	P	A	h IFN Omega 1_G130T
121	T	C	L	L	Q	V	V	G	E	N	E	S	A	G	A	I	S	S	P	A	h IFN Omega 1_G130N
121	T	C	L	L	Q	V	V	G	E	N	E	S	A	G	A	I	S	S	P	A	h IFN Omega 1_R95N_G130N
121	T	C	L	L	Q	V	V	G	E	T	E	S	A	G	A	I	S	S	P	A	h IFN Omega 1_R95N_G130T

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Figure 30

		M A L K F A L Q I A L V V L S S T S A L	Majority
		10 20	
1		M - - - - - - - - - - - - - - - - - -	Infergen
1		M A L P F A L M M A L V V L S C K S S C	Infergen w A14 Sig
1		M A L P F A L M M A L V V L S C K S S C	h IFN alpha 14
1		M T N K C L L Q I A L L L C F S T T A L	Infergen w Beta Sig
1		M T N K C L L Q I A L L L C F S T T A L	h IFN beta 1
		S L G C D L P Q - T H S L G N R R A L I	Majority
		30 40	
2		- - - C D L P Q - - - T H S L G N R R A L I	Infergen
21		S L G C D L P Q - - - T H S L G N R R A L I	Infergen w A14 Sig
21		S L G C D L P Q - - - T H S L G N R R A L I	h IFN alpha 14
21		S M S C D L P Q - - - T H S L G N R R A L I	Infergen w Beta Sig
21		S M S C D L P Q - - - T H S L G N R R A L I	h IFN beta 1
		L L A Q M R R I S P F S C L K D R H D F	Majority
		50 60	
18		L L A Q M R R I S P F S C L K D R H D F	Infergen
40		L L A Q M R R I S P F S C L K D R H D F	Infergen w A14 Sig
40		L L A Q M R R I S P F S C L K D R H D F	h IFN alpha 14
40		L L A Q M R R I S P F S C L K D R H D F	Infergen w Beta Sig
41		L L W Q L N G R L E Y - C L K D R M N F	h IFN beta 1
		G F P Q E E F D G N Q F Q K A Q A I S V	Majority
		70 80	
38		G F P Q E E F D G N Q F Q K A Q A I S V	Infergen
60		G F P Q E E F D G N Q F Q K A Q A I S V	Infergen w A14 Sig
60		G F P Q E E F D G N Q F Q K A Q A I S V	h IFN alpha 14
60		G F P Q E E F D G N Q F Q K A Q A I S V	Infergen w Beta Sig
60		D I P E E I K Q L Q Q F Q K E D A A L T	h IFN beta 1
		L H E M I Q Q T F N L F S T K D S S A A	Majority
		90 100	
58		L H E M I Q Q T F N L F S T K D S S A A	Infergen
80		L H E M I Q Q T F N L F S T K D S S A A	Infergen w A14 Sig
80		L H E M I Q Q T F N L F S T K D S S A A	h IFN alpha 14
80		L H E M I Q Q T F N L F S T K D S S A A	Infergen w Beta Sig
80		I Y E M L Q N I F A I F R Q D S S S T G	h IFN beta 1
		W D E S L L E K F Y T E L Y Q Q L N D L	Majority
		110 120	
78		W D E S L L E K F Y T E L Y Q Q L N D L	Infergen
100		W D E S L L E K F Y T E L Y Q Q L N D L	Infergen w A14 Sig
100		W D E S L L E K F Y T E L Y Q Q L N D L	h IFN alpha 14
100		W D E S L L E K F Y T E L Y Q Q L N D L	Infergen w Beta Sig
100		W N E T I V E N L L A N V Y H Q I H H L	h IFN beta 1
		E A C V I Q E V G V E E T P L M N V D S	Majority
		130 140	
98		E A C V I Q E V G V E E T P L M N V D S	Infergen
120		E A C V I Q E V G V E E T P L M N V D S	Infergen w A14 Sig
120		E A C V I Q E V G V E E T P L M N V D S	h IFN alpha 14
120		E A C V I Q E V G V E E T P L M N V D S	Infergen w Beta Sig
120		K T V L E S K L E K E D F T R G K L M S	h IFN beta 1
		I L A V K K Y F Q R I T L Y L T E K K Y	Majority
		150 160	
118		I L A V K K Y F Q R I T L Y L T E K K Y	Infergen
140		I L A V K K Y F Q R I T L Y L T E K K Y	Infergen w A14 Sig
140		I L A V K K Y F Q R I T L Y L T E K K Y	h IFN alpha 14
140		I L A V K K Y F Q R I T L Y L T E K K Y	Infergen w Beta Sig
140		S L H L K R Y Y G R I L H Y L K A K E Y	h IFN beta 1
		S P C A W E V V R A E I M R S F S L S T	Majority
		170 180	
138		S P C A W E V V R A E I M R S F S L S T	Infergen
160		S P C A W E V V R A E I M R S F S L S T	Infergen w A14 Sig
160		S P C A W E V V R A E I M R S F S L S T	h IFN alpha 14
160		S P C A W E V V R A E I M R S F S L S T	Infergen w Beta Sig
160		S H C A W T I V R H E I L R N F Y F I N	h IFN beta 1
		N L Q E R L R R K E	Majority
		190	
158		N L Q E R L R R K E	Infergen
180		N L Q E R L R R K E	Infergen w A14 Sig
180		N L Q E R L R R K E	h IFN alpha 14
180		N L Q E R L R R K E	Infergen w Beta Sig
180		R L T G Y L R - - N	h IFN beta 1

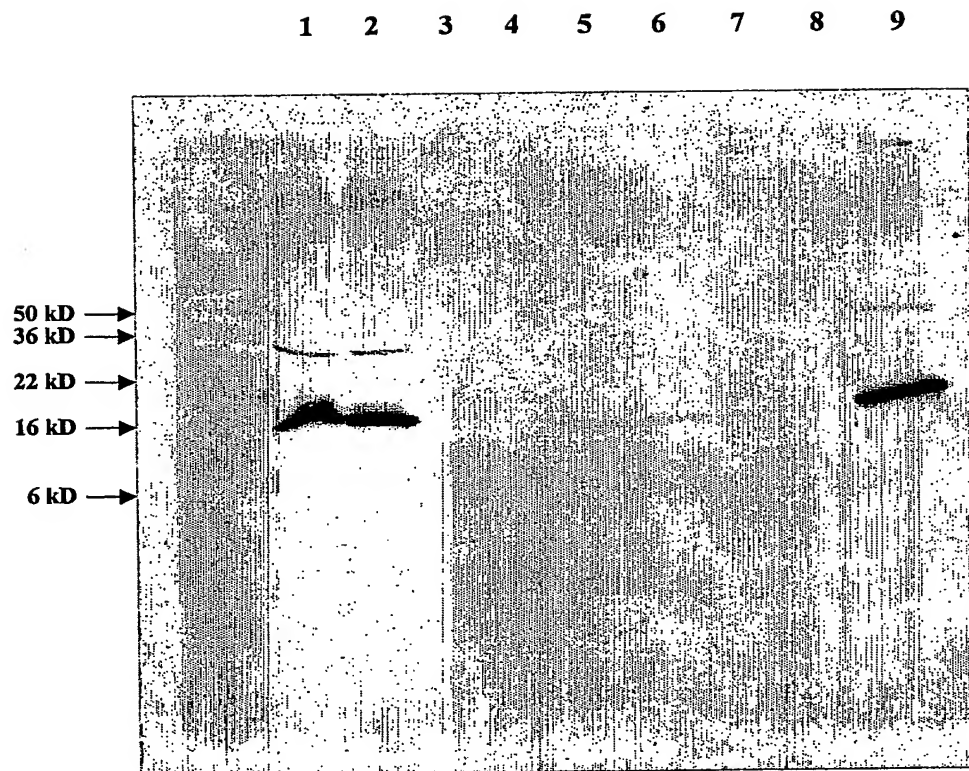
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**Figure 31**human IFN- $\gamma$  amino acid sequence

Gln Asp Pro Tyr Val Lys Glu Ala Glu Asn Leu Lys Lys Tyr Phe Asn  
1 5 10 15  
Ala Gly His Ser Asp Val Ala Asp Asn Gly Thr Leu Phe Leu Gly Ile  
20 25 30  
Leu Lys Asn Trp Lys Glu Glu Ser Asp Arg Lys Ile Met Gln Ser Gln  
35 40 45  
Ile Val Ser Phe Tyr Phe Lys Leu Phe Lys Asn Phe Lys Asp Asp Gln  
50 55 60  
Ser Ile Gln Lys Ser Val Glu Thr Ile Lys Glu Asp Met Asn Val Lys  
65 70 75 80  
Phe Phe Asn Ser Asn Lys Lys Lys Arg Asp Asp Phe Glu Lys Leu Thr  
85 90 95  
Asn Tyr Ser Val Thr Asp Leu Asn Val Gln Arg Lys Ala Ile His Glu  
100 105 110  
Leu Ile Gln Val Met Ala Glu Leu Ser Pro Ala Ala Lys Thr Gly Lys  
115 120 125  
Arg Lys Arg Ser Gln Met Leu Phe Arg Gly Arg Arg Ala Ser Gln  
130 135 140

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Figure 32



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